Volume 18 Study G-I-R

STATE OF ALASKA

Jay S. Hammond, Governor

Annual Performance Report for

INVENTORY OF HIGH QUALITY RECREATIONAL FISHING WATERS IN SOUTHEAST ALASKA

by

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Inventory of High Quality Recreational Fishing Waters in Southeast Alaska

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RESEARCH PROJECT SEGMENT

State:	ALASKA	Name:	Sport Fish Investigations of Alaska
Project No.:	F-9-9		
Study No.:	G-I	Study Title:	INVENTORY & CATALOGING
Job No.:	G-I-R	Job Title:	Inventory of High Quality Recreational Fishing Waters in Southeast Alaska

Period Covered: July 1, 1976 to June 30, 1977

ABSTRACT

Limnological investigations and recreational analyses were conducted on the Sarkar lakes in an attempt to (1) determine the relationship of physical, chemical, and biological characteristics to fish production and (2) protect this high-quality fishing and recreational area from undesirable development.

Intensive limnological investigations were conducted on two of five lakes throughout the summer. Other lakes were each studied for a one-week period. Sarkar Lake was visited during two, one-week periods. Recreational analyses were conducted on all lakes.

Lakes of the Sarkar system are quite shallow. None has a mean depth greater than 11 meters. A comparison of productivity potential by the morphoedaphic index shows Tammy and Finger lakes as the most productive studied in southeast Alaska to date. Plankton indices show the Sarkar lakes to be quite productive when compared with other southeast Alaska systems. The presence of Chaoborus sp. larvae in plankton samples throughout the summer may indicate a paucity of rearing sockeye salmon, Oncorhynchus nerka (Walbaum).

The Sarkar system contains coho, O. kisutch (Walbaum), chum, O. keta (Walbaum), pink, O. gorbuscha (Walbaum), and sockeye salmon; steelhead, Salmo gairdneri Richardson, and resident and sea-run cutthroat trout, S. clarki Richardson; and Dolly Varden, Salvelinus malma (Walbaum). The lakes are especially suited to cutthroat trout.

Recreational analyses indicate that the system should be developed into two areas. The easy access area, Sarkar Lake, should have facilities including boat ramp, picnic area, trails, and possibly a bear observatory. The limited access area would be a canoe route through Finger, Raven, and Long lakes. The highlight of the Sarkar system is the abundance and diversity of its mammalian and avian fauna.

BACKGROUND

Limnological investigations have been conducted in several lakes in southeast Alaska (Schmidt, 1974; Schmidt and Robards, 1975; Schmidt, 1976). One continuing objective of this project is to determine the relationship of physical, chemical, and biological characteristics to fish production.

The Alaska Department of Fish and Game, Sport Fish Division, has long attempted to obtain additional protection for high-quality fishing waters. In 1972 the Alaska Department of Fish and Game made an official request to the forest supervisor of the Tongass National Forest to give special consideration to 18 identified high-quality watersheds. This investigation was conducted in an attempt to further quantify the recreational value and limnological relationships of one of the previously mentioned 18 watersheds.

RECOMMENDATIONS

Management

The Sarkar system drainage should be classified according to the U.S. Forest Service classification plan so that the recreational values will not be destroyed or allowed to deteriorate. No logging or undesirable development should take place in the headwater lakes and streams. An illustrated informational pamphlet describing the recreational value of the Sarkar system should be prepared for the public.

Research

Similiar investigations should be conducted on other high-quality recreation areas. An attempt should be made to protect all high-quality fishing waters from undesirable development.

OBJECTIVES:

1. Determine the relationship of physical, chemical, and biological characteristics of selected lakes to fish production.

2. Identify and protect from undesirable development high-quality recreational fishing waters in southeast Alaska.

3. Determine recreational fishing potential of the Sarkar system on Prince of Wales Island.

TECHNIQUES USED

Relationship of Limnological Characteristics to Fish Production

Limnological relationships existing in five lakes of the Sarkar system on Prince of Wales Island were investigated. These included Tammy

Finger, Moss, and Raven lakes and Sarkar Lake, a saltwater estuary at the downstream terminus of the lake system (Figure 1).

Bathymetric maps were prepared from each of the Tammy, Finger, and Raven lakes. A recording fathometer was used to record depth contours on transects crossing each lake. The depth contours were transferred to bathymetric maps, and morphometric data were calculated from these maps.

Personnel from the Department of Fish and Game made a field collection trip to Tammy and Finger lakes on October 13, 1976. These collections were timed to coincide with the fall turnover period. Sampling stations were established at approximately the deepest portion of each lake. Vertical profiles of temperature and specific conductance were recorded at each station. Water samples for comprehensive chemical analyses were collected and preserved at each station. Field chemical analyses, including alkalinity titrations, were conducted according to Standard Methods (1971). Comprehensive chemical analyses on preserved samples were conducted by the Alaska Department of Environmental Conservation laboratory in Douglas, Alaska.

Collection trips to Larry, Ludvik, Osprey and Tranquil lakes on Baranof Island were conducted October 11 and 12, 1976. Field and laboratory chemical analyses were conducted identical to those on Tammy and Finger lakes.

Intensive limnological and fishery investigations were conducted on the Sarkar lakes. All lakes of this system are open to anadromous fish. Tammy and Finger lakes were sampled every third week. A one-week investigation was conducted on each of the other lakes. Sarkar Lake was visited during two weekly sampling periods.

Zooplankton were collected biweekly by making duplicate vertical tows from the lake bottom with each of two nets. Nets used were 0.5 m diameter and 3 m long. Straining cloth of the No. 10 Nitex net had aperture of 153 microns and 45% open area, while the No. 20 Nitex net had aperture of 80 microns and 35% open area. Plankton were identified and counted. Dry and ash weight of plankton were determined gravimetrically. Efficiency of nets was not accounted for in calculations. Thermal profiles and Secchi disc readings were taken in conjunction with plankton tows.

Stream drift organisms were collected biweekly by placing two nets in the main inlet. Nets used were 12 inches square, 3 feet long, made with Nitex with pore size of 280 microns, and 45% open area. Benthos were preserved and later identified and enumerated in the laboratory.

Bottom fauna were collected by dredging with an Ekman 6-inch dredge. Bottom samples were washed through three screens, the finest having 28 meshes per inch. Organisms were preserved in 70% ethyl alcohol or frozen until laboratory analysis.

Age, growth, and food habits of fish in the lakes were determined from fish collected throughout the study period.

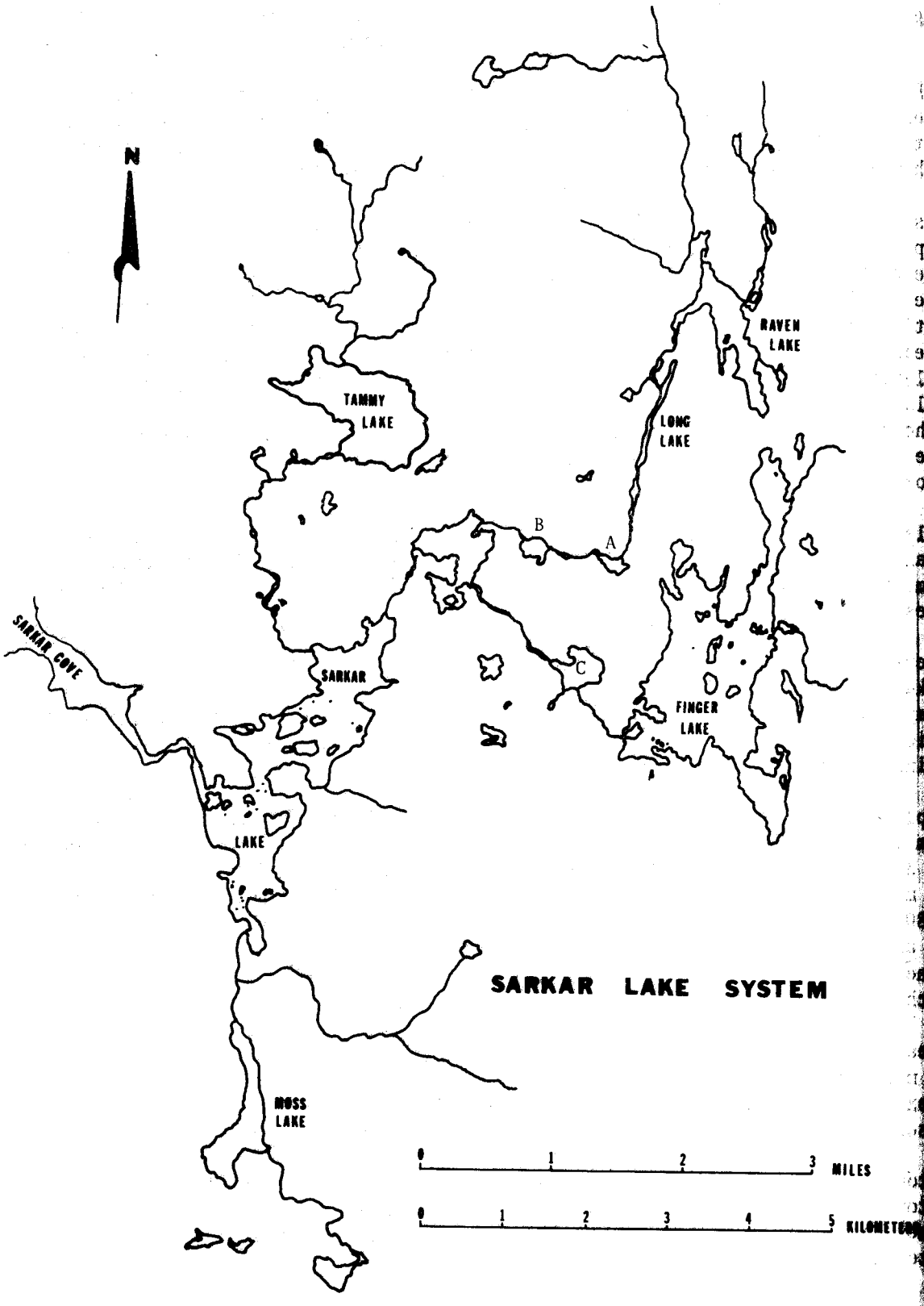


Figure 1. Sarkar system drainage showing relative location of major lakes

Protection of High-Quality Recreational Fishing Waters

A review of high-quality recreational waters was conducted to determine which were in danger of undesirable development. The Sarkar drainage of Prince of Wales Island was chosen for study.

The recreational potential of the Sarkar system as an entity and the recreational potential of each of the lakes was evaluated. Information evaluated included present and future recreational opportunity and importance, proximity to other recreational areas, uniqueness of the area, ability of the system to support a viable fishery, accessibility, and aesthetics.

FINDINGS

Relationship of Limnological Characteristics to Fish Production

Morphometry:

The depth, size, and shape of lakes strongly influence physical and chemical conditions which prevail in them. Since physical and chemical parameters limit species composition and abundance of organisms, it is essential to study the morphometric features of lakes. Bathymetric maps of Finger Lake (Figure 2), Raven Lake (Figure 3), and Tammy Lake (Figure 4) were prepared from sounding data. Morphometric data for these lakes are presented in Tables 1 through 3, respectively. Finger, Raven, and Tammy lakes have mean depths of 10.7 m, 7.1 m, and 10.0 m, respectively. Moss Lake is much shallower with a maximum depth of 4.5 m. Sarkar Lake is quite shallow. Most of the lagoon is 3 m or less, but one area has a maximum depth of 12.5 m.

Physical and Chemical Considerations:

Observations of temperature, pH, Secchi disc visibility, conductivity, and alkalinity were made on each lake during the survey period. Locations of sampling stations on Finger, Moss, Raven, Sarkar, and Tammy lakes are shown in Figures 5 through 9, respectively.

Thermal profiles of Finger and Tammy lakes are shown in Figures 10 and 11; thermal profiles of Moss and Raven lakes are shown in Figure 12. All lakes were holomictic, having two circulation periods per year. Pronounced thermal stratification during the summer season varied from 2 to 10 m depending upon wind conditions. On October 13 the lakes had turned over and were homothermous from top to bottom.

Secchi disc visibility in Finger and Tammy lakes was about 12 m in early summer (Figure 13) but decreased to less than 4 m after late June.

Alkalinity, conductivity, and pH of all systems are summarized in Table 4. Alkalinity, conductivity, and pH of Finger, Tammy, and Raven are very similar, indicating similar productivity. Moss Lake has a much higher conductivity, alkalinity, and pH and should rank much higher on a produc-

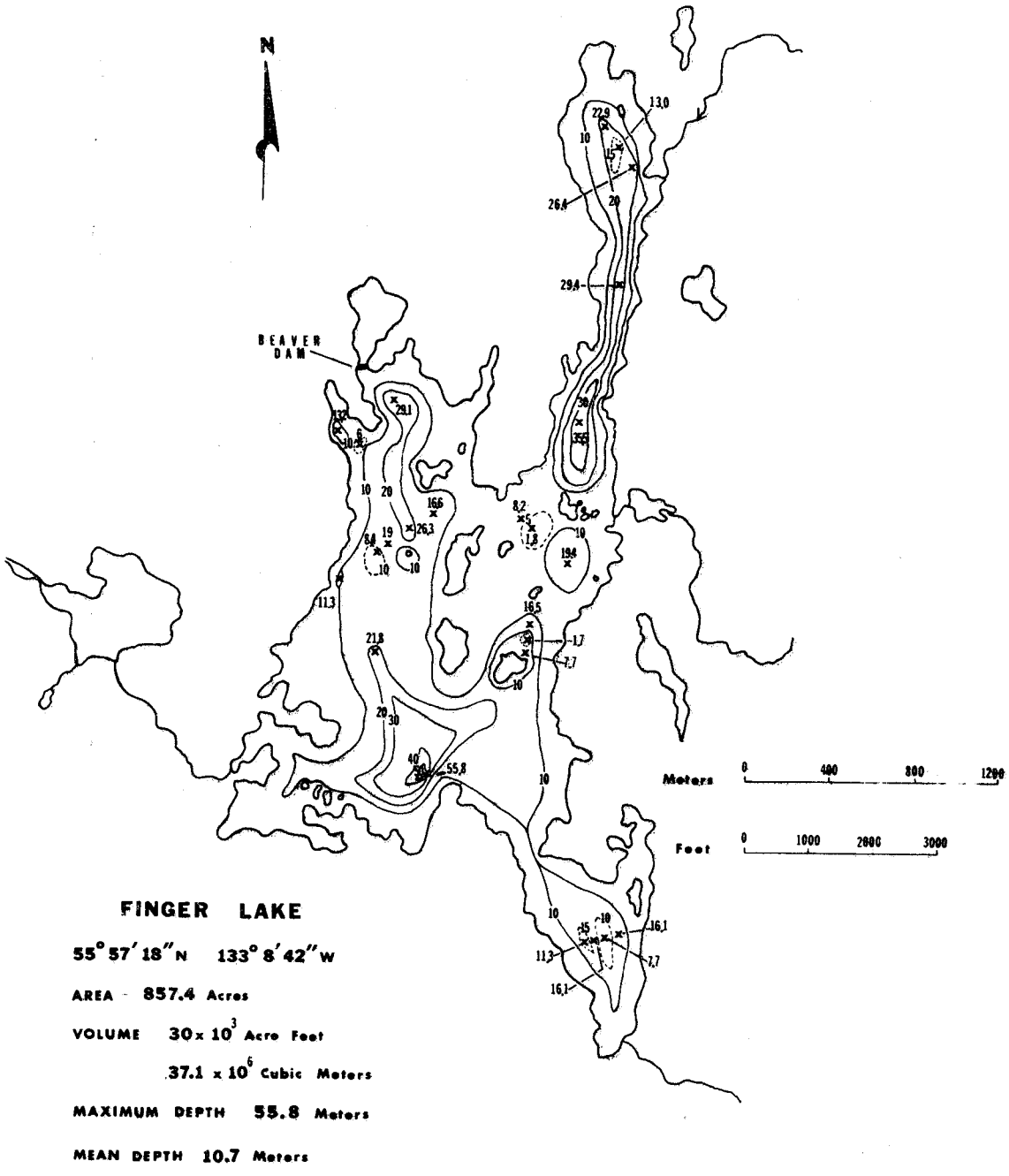


Figure 2. Bathymetric map of Finger Lake.

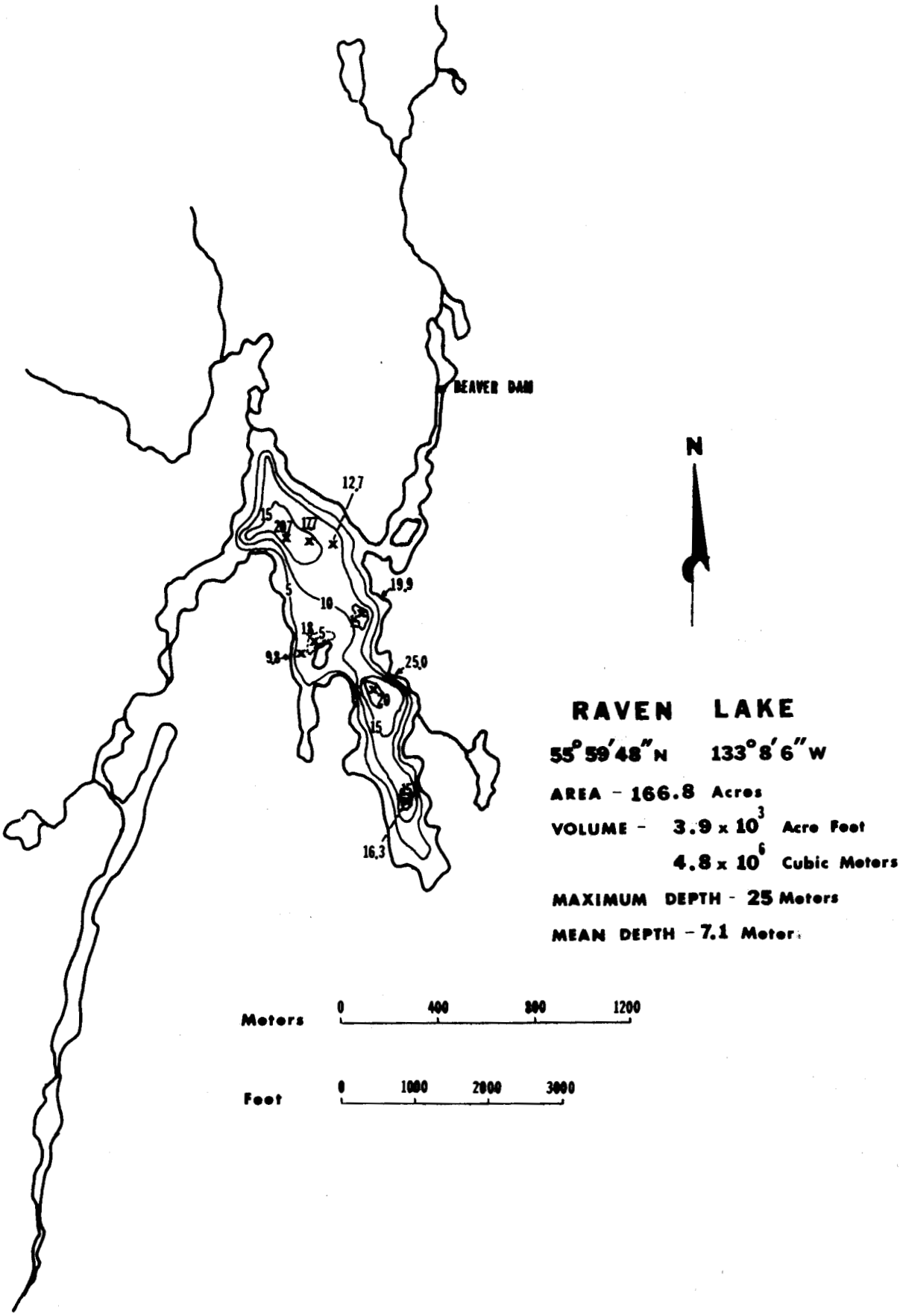


Figure 3. Bathymetric map of Raven Lake.

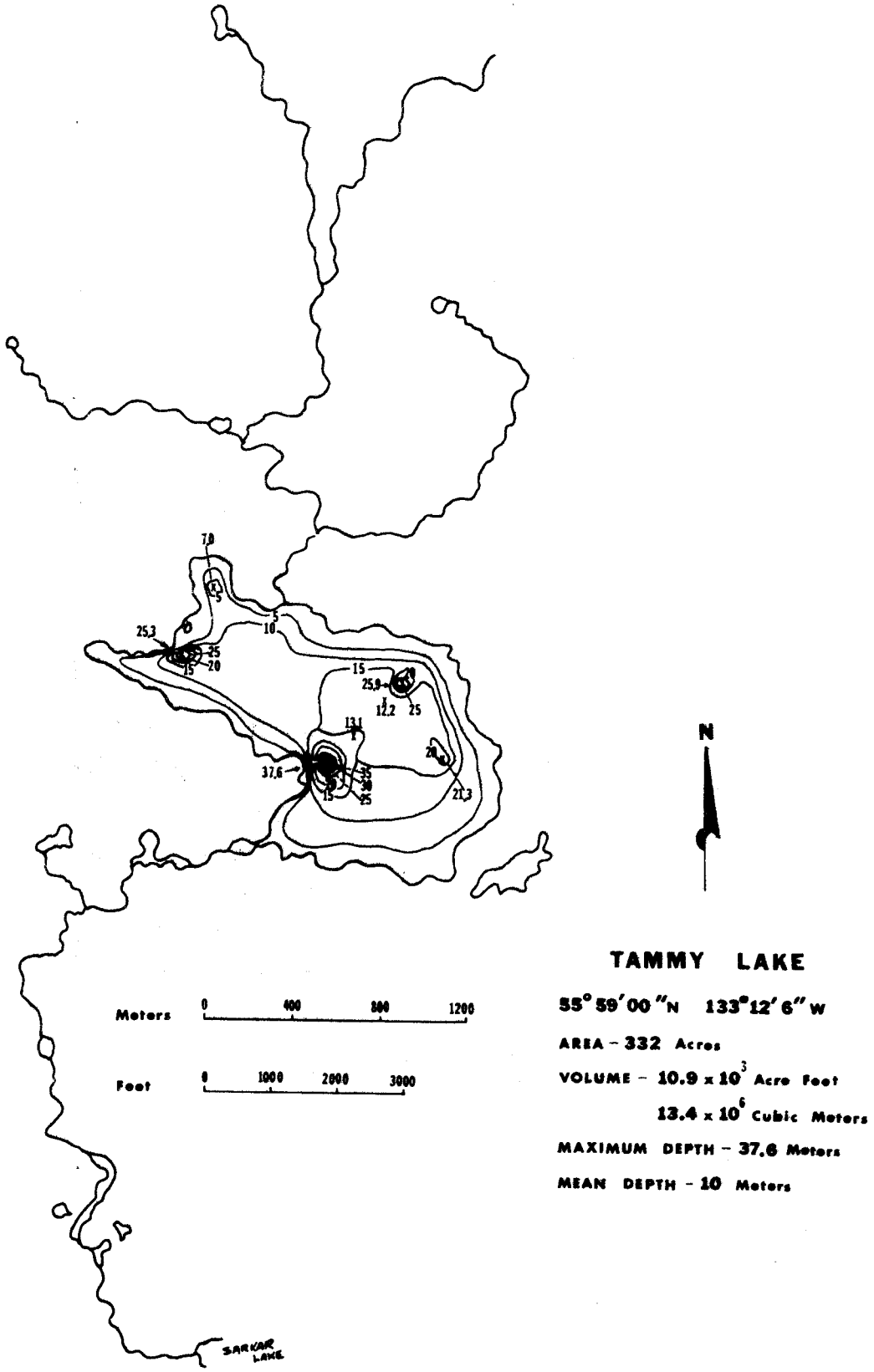


Figure 4. Bathymetric map of Tammy Lake.

Table 1. Morphometry of Finger Lake.

Island Area 10.1 ha or 24.9 acres

Water Area 347.0 ha or 857.0 acres

Area by Depth Zone

Depth Zone (m)	Area (m^2)	Percent of Total Area
0-10	1,867,691	53.8
10-20	1,204,387	34.7
20-30	280,457	8.1
30-40	106,841	3.1
40-50	8,903	0.2
50+	1,619	0.1

Water Volume

Cubic Meters 37.1×10^6

Acre Feet 30.1×10^3

Volume by Depth Zone

Depth Zone (m)	Volume (m^3)	Percent of Total Volume
0-10	24,766,543	66.7
10-20	9,327,980	25.1
20-30	2,437,534	6.6
30-40	543,420	1.5
40-50	54,228	0.1
50+	3,209	

Maximum Depth = 55.8 m

Mean Depth = 10.7 m

Shoreline Length = 27,192.0 m

Shoreline Development = 5.6

Table 2. Morphometry of Raven Lake.

Island Area 1.8 ha or 4.4 acres

Water Area 67.5 ha or 166.7 acres

Area by Depth Zone

Depth Zone (m)	Area (m^2)	Percent of Total Area
0- 5	309,191	45.8
5-10	159,857	23.7
10-15	134,765	20.0
15-20	63,942	9.5
20-25	6,071	0.9
25+	1,214	0.2

Water Volume

Cubic Meters 4.8×10^6

Acre Feet 3.9×10^3

Volume by Depth Zone

Depth Zone (m)	Volume (m^3)	Percent of Total Volume
0- 5	2,563,071	53.1
5-10	1,410,604	29.2
10-15	663,913	13.8
15-20	168,818	3.5
20-25	19,121	0.4
25+		

Maximum Depth = 25.0 m

Mean Depth = 7.1 m

Shoreline Length = 9,493.0 m

Shoreline Development = 3.2

Table 3. Morphometry of Tammy Lake.

Island Area 0.08 ha or 0.2 acres

Water Area 134.20 ha or 331.5 acres

Area by Depth Zone

Depth Zone (m)	Area (m^3)	Percent of Total Area
0- 5	337,115	25.1
5-10	319,713	23.8
10-15	397,820	29.6
15-20	245,248	18.3
20-25	23,473	1.7
25-30	11,736	0.9
30-35	4,452	0.3
35+	2,833	0.2

Water Volume

Cubic Meters 13.4×10^6

Acre Feet 10.8×10^3

Volume by Depth Zone

Depth Zone (m)	Volume (m^3)	Percent of Total Volume
0- 5	5,848,887	43.7
5-10	4,201,674	31.4
10-15	2,362,415	17.6
15-20	734,689	5.5
20-25	149,906	1.1
25-30	63,460	0.5
30-35	24,434	0.2
35+	2,502	

Maximum Depth = 37.6 m

Mean Depth = 10.0 m

Shoreline Length = 6,957.0 m

Shoreline Development = 1.7

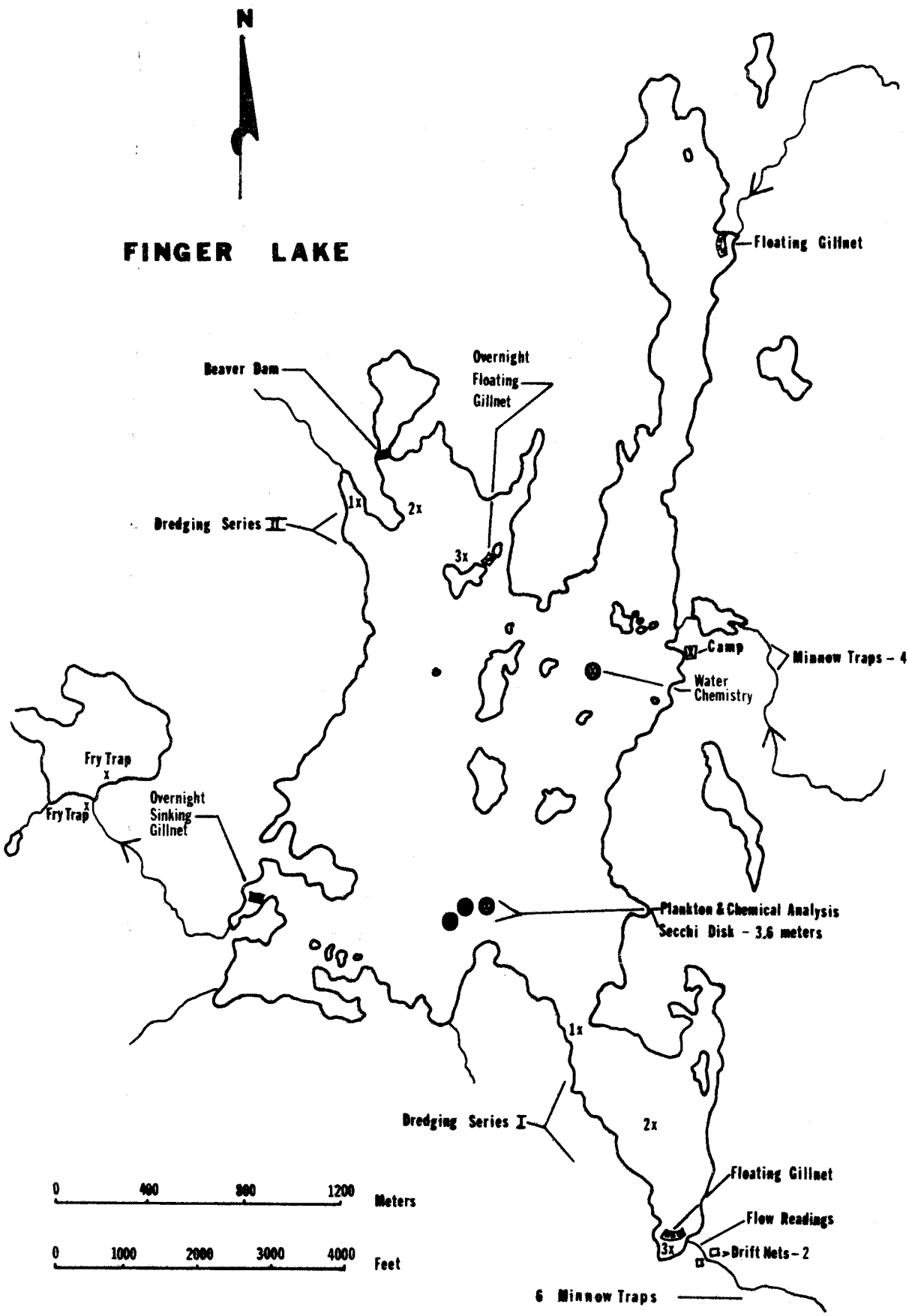


Figure 5. Map showing location of sampling stations, Finger Lake, 1976.

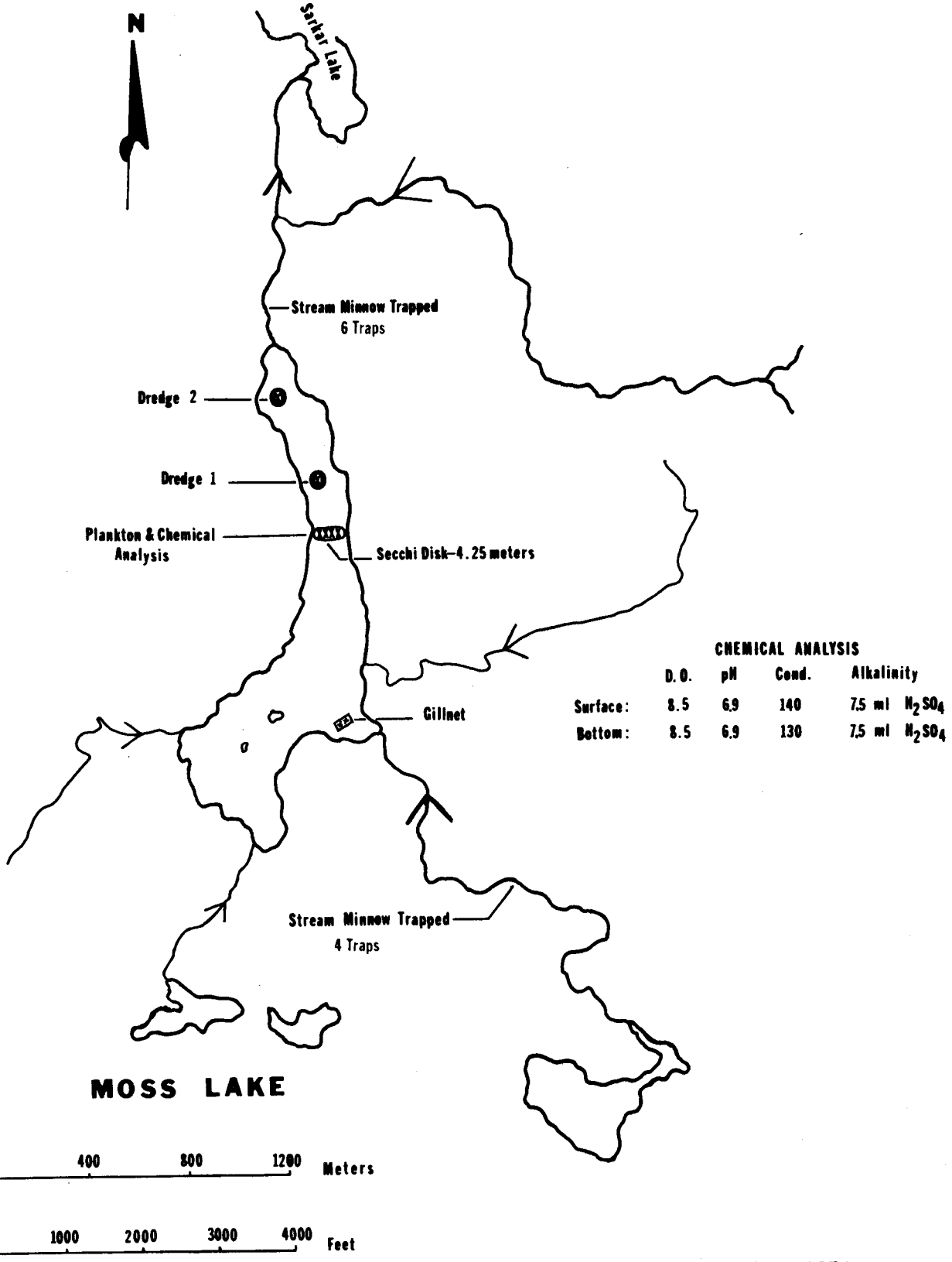


Figure 6. Map showing location of sampling stations, Moss Lake, 1976.

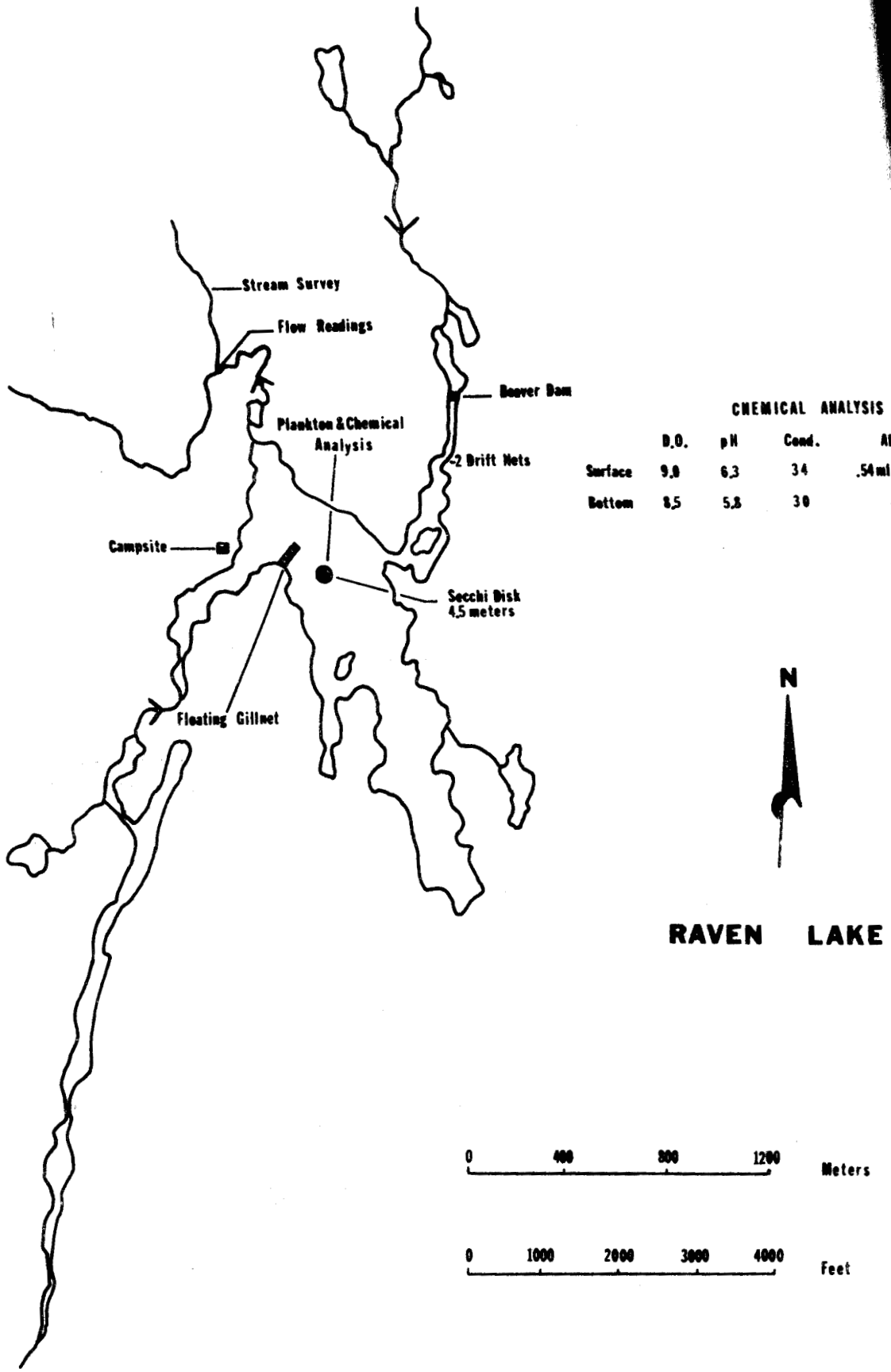


Figure 7. Map showing location of sampling stations, Raven Lake, 1976.

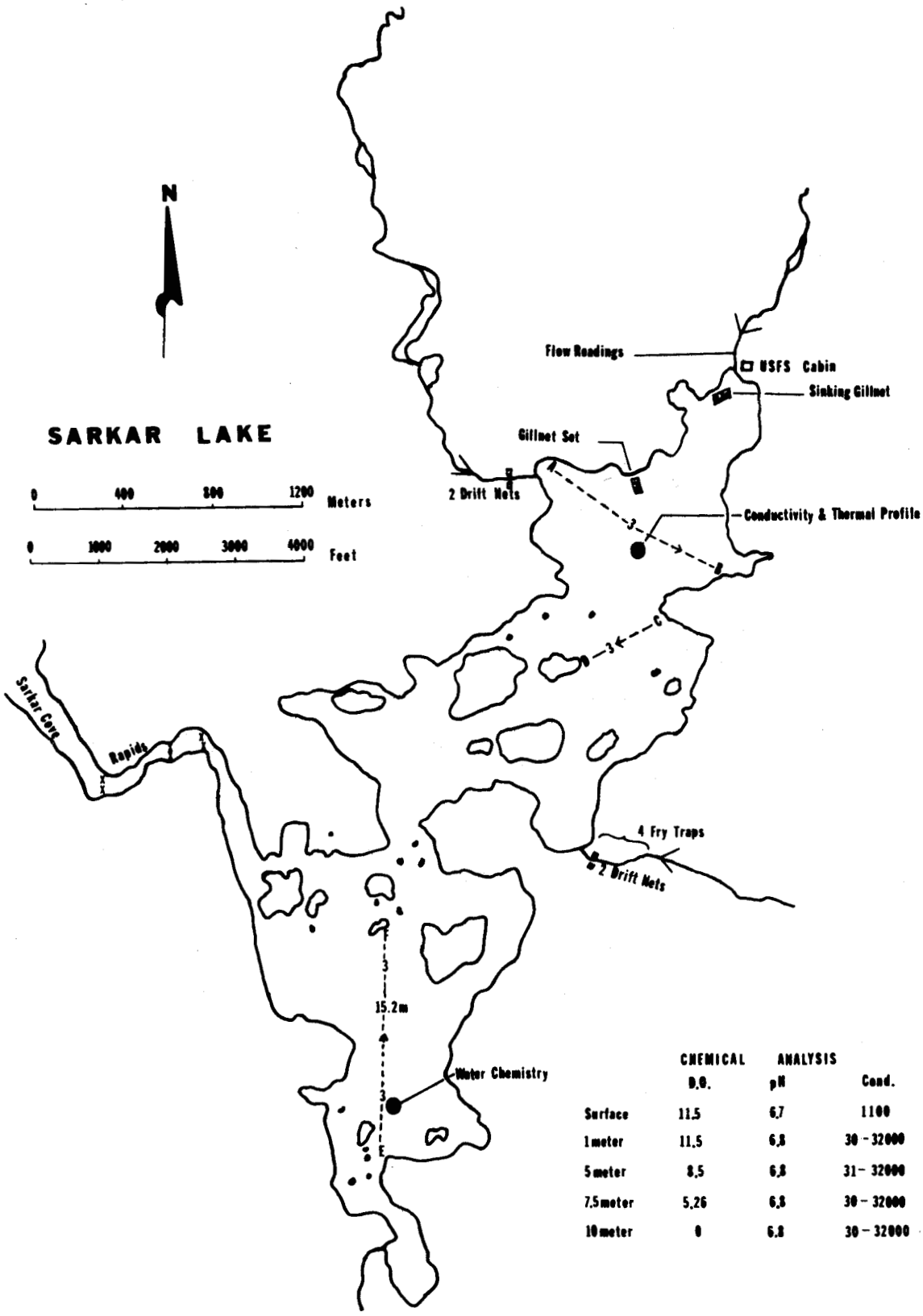


Figure 8. Map showing location of sampling stations, Sarkar Lake, 1976.

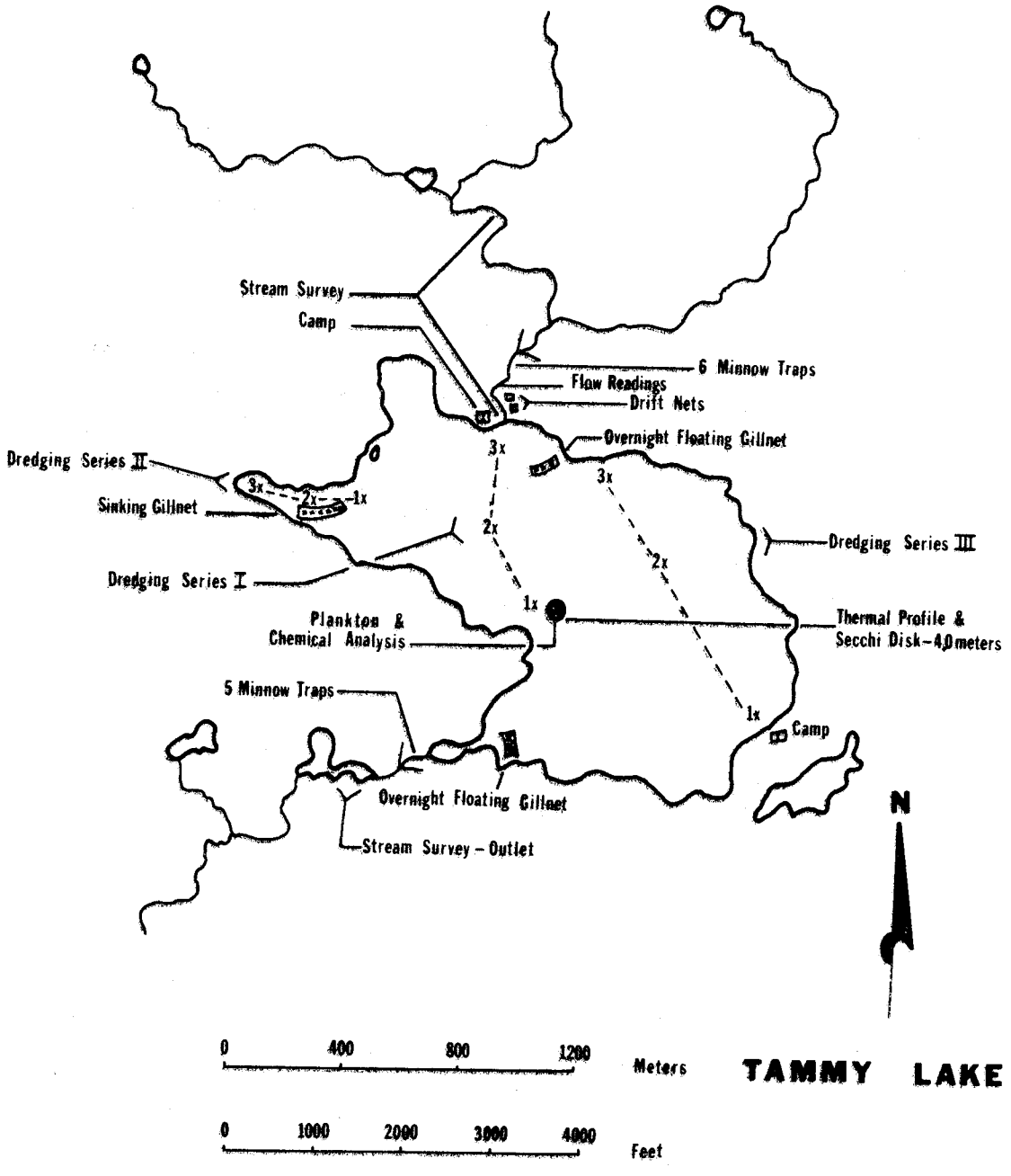


Figure 9. Map showing location of sampling stations, Tammy Lake, 1976

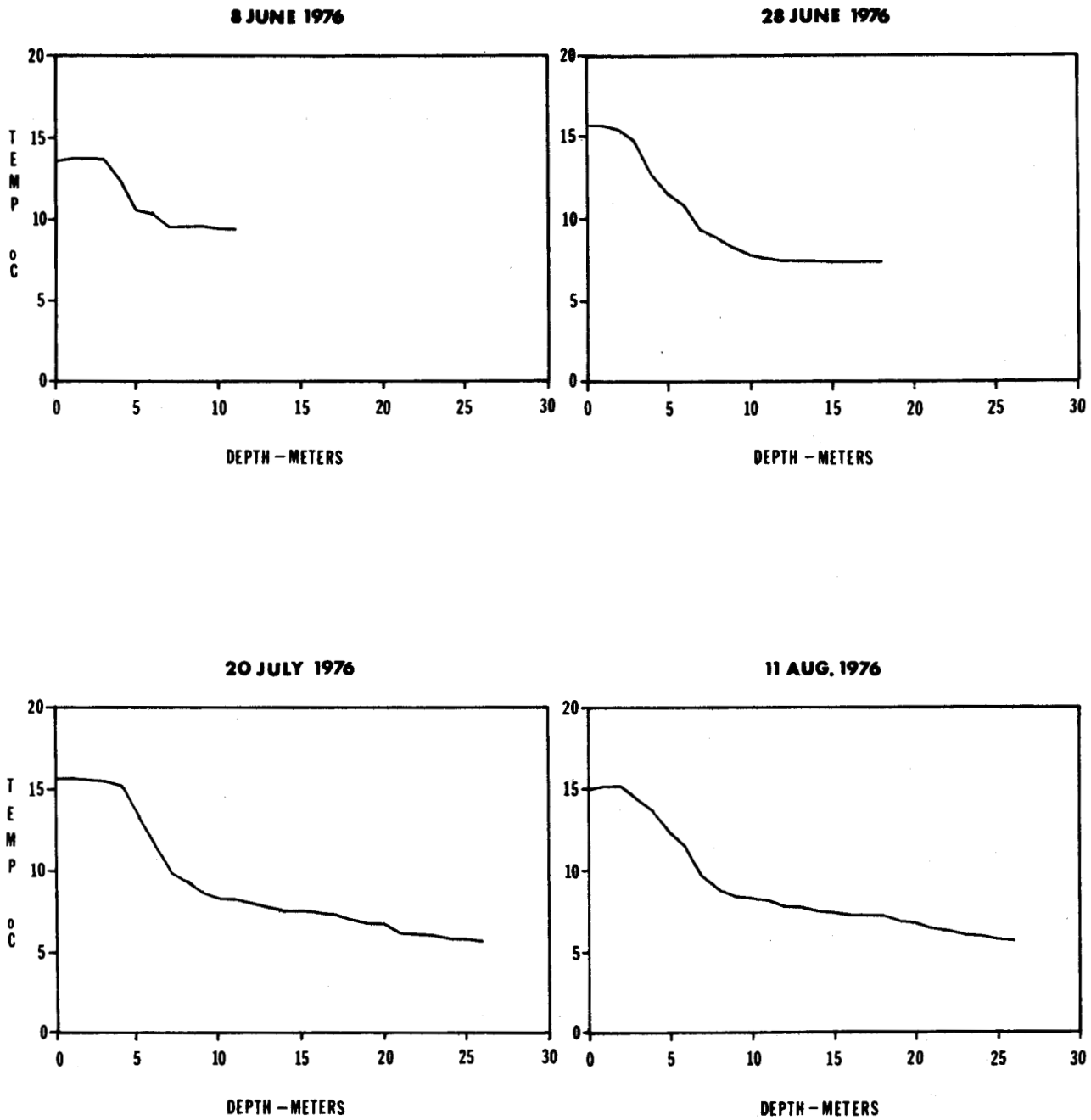


Figure 10. Thermal profiles of Finger Lake, 1976.

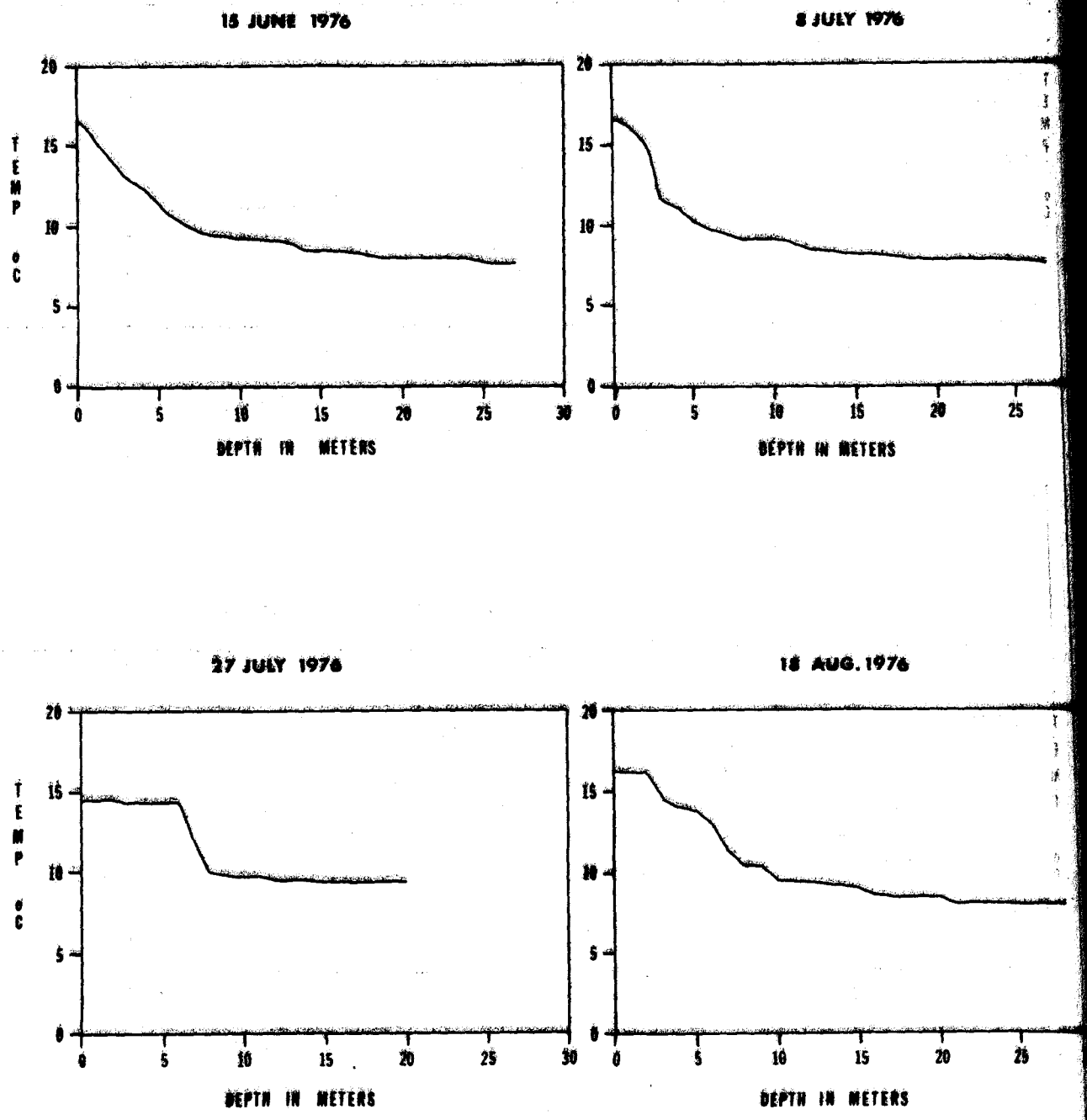
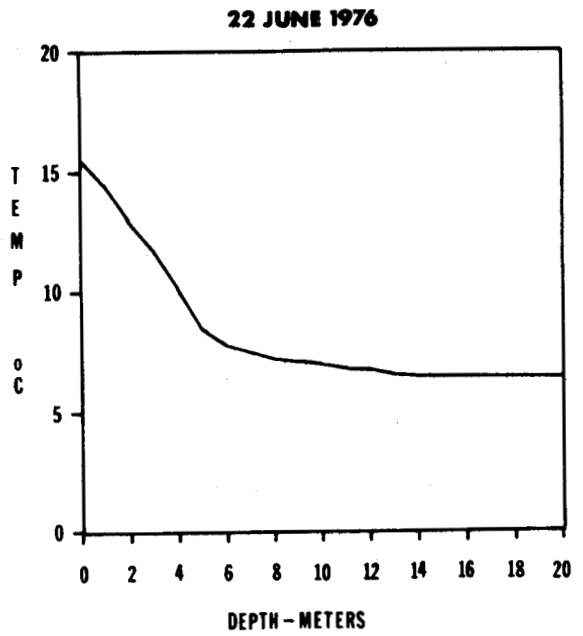
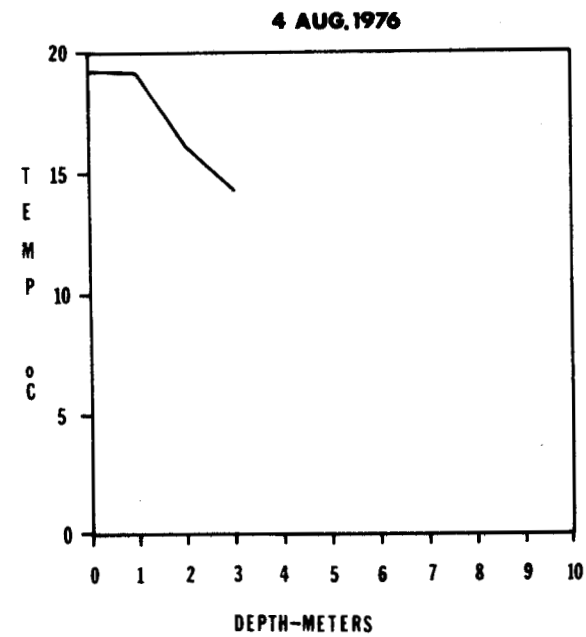


Figure 11. Thermal profiles of Tammy Lake, 1976.



RAVEN LAKE



MOSS LAKE

Figure 12. Thermal profiles of Moss and Raven lakes, 1976.

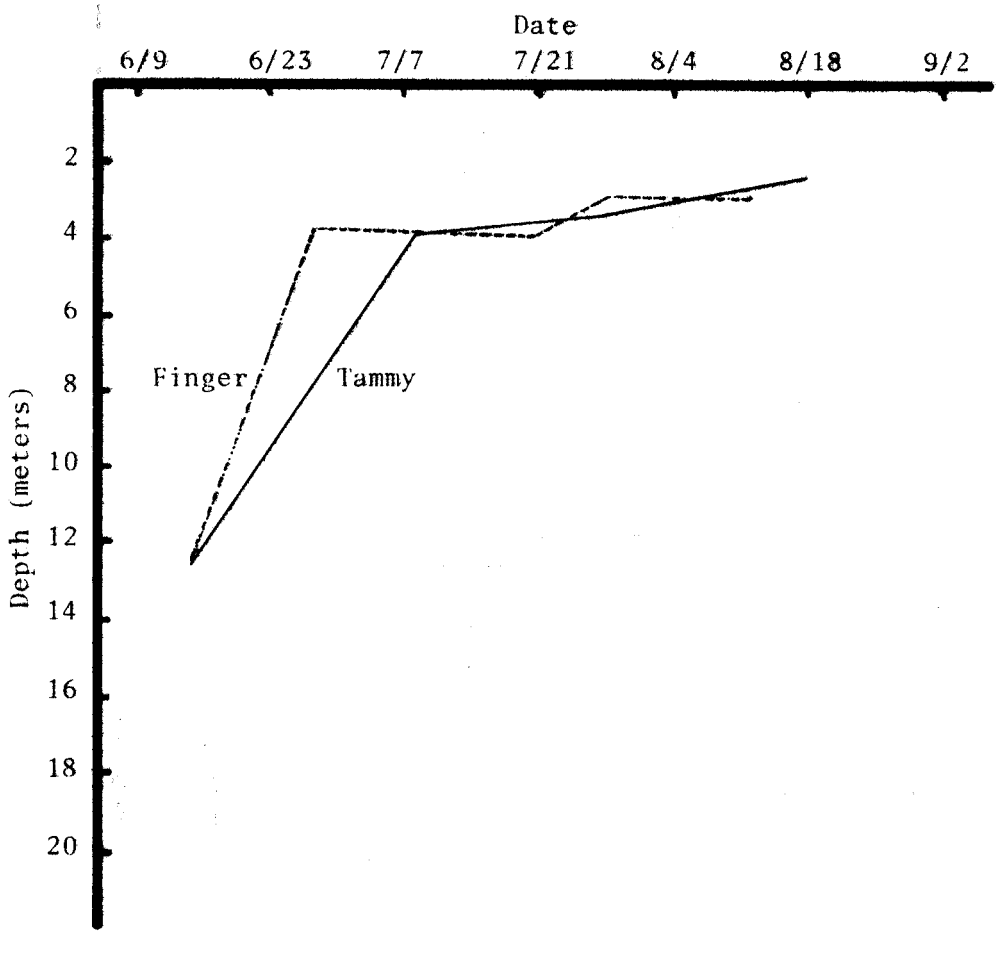


Figure 13. Secchi disc visibility, Finger and Tammy lakes, 1976.

Table 4. Alkalinity, conductivity, and pH, Sarkar lakes, 1976.

Lake	Alkalinity (mg/l)	Conductivity (μ mhos)	pH
Finger	6.4-8.1	20- 35 28- 32	6.5
Moss	87.0	135	6.9
Raven	6.3	32	6.2
Sarkar		300-32,000	6.7-6.8
Tammy	4.1-4.2	25- 32	6.2

tivity potential scale. Sarkar Lake is primarily salt water with conductivity and pH similar to ocean water. Only the top half meter or less of Sarkar Lake has a freshwater lens. The bottom layer of Sarkar is anerobic, stagnant salt water.

Quantitative analyses of ions from lakes studied are presented in Table 5.

The morphoedaphic index (Ryder, 1964; 1965) is an empirically-derived formula that was described initially as a convenient method of rapidly calculating potential fish yields from unexploited north-temperate lakes. Since its inception, the constraints on the use of the morphoedaphic index (MEI) have been relaxed, as it has been applied to sets of lakes other than those for which it was originally devised. Various investigators have clarified our understanding of the MEI (e.g., Jenkins, 1967; Regier et al., 1971; Henderson et al., 1973) and have extended the application of this index to other climatic systems.

The MEI for all lakes studied so far in southeast Alaska is presented in Table 6. This shows a ranking of lakes from the most productive, Finger Lake, to the least productive, Swan Lake. The lakes of the Sarkar system appear at the top of the comparative productivity scale.

Plankton:

Zooplankton populations were monitored throughout the summer at Finger Lake (Table 7) and Tammy Lake (Table 8). Zooplankton was collected only once from Moss and Raven lakes (Table 9). Zooplankton sampled from Osprey Lake on Baranof Island are listed in Table 10.

Species composition of zooplankton in Finger, Raven, and Tammy lakes was nearly identical. The only major difference was that Tammy Lake did not contain any Diaptomus sp. All three of these lakes maintained populations of Chaoborus sp. larvae and populations of the larger copepods. This either indicates a scarcity of rearing sockeye, Oncorhynchus nerka (Walbaum), and coho salmon, O. kisutch (Walbaum), or an abundance of Chaoborus sp. due to high productivity of these lakes. Usually Chaoborus sp. larvae and larger copepods are selectively fed upon by rearing sockeye and coho salmon. No Chaoborous sp. or copepods were captured in Moss Lake although water chemistry analyses indicate this to be the most productive of the four freshwater lakes. I suspect Moss Lake has the most dense population of rearing fish and Tammy Lake has the second most dense population.

Although a standing crop of plankton does not measure production, net plankton samples may show some distinction between oligotrophic and eutrophic lakes. Rawson (1953) stated that the standing crop of No. 20 net plankton measured by total vertical hauls exhibits this distinction in western Canada. He gives this range as 10 to 40 kg/ha dry weight for alpine and large oligotrophic lakes, while mesotrophic and moderately eutrophic lakes have up to 100 kg/ha.

The standing crop of No. 20 net plankton was calculated using an assumed net efficiency of 25%. The organic weight of the four heaviest plankton

Table 5. Water quality and nutrient analysis* of selected southeast Alaska lakes, 1976.

Lake and Date	Depth (m)	Alkalinity ($CaCO^3$) (mg/l)	Calcium (mg/l)	Conductivity (micromhos)	Fluoride (mg/l)	Iron (mg/l)	Magnesium (mg/l)	Manganese (mg/l)	Nitrate (mg/l)	pH Units	Potassium (mg/l)	Sodium (mg/l)	Temperature (^oC)
Finger, October 13	0.3	8.1	3.4	28	0.02	0.2	330	17	0.30	6.5	87	1.3	10.8
Larry, October 11	0.3	1.4	0.4	10	0.02	ND	130	17	0.23	5.5	30	1.1	9.2
Ludvik, October 12	0.3	2.3	0.5	72	0.02	ND	150	12	0.33	6.2	60	1.0	9.0
Osprey, October 11	0.3	4.4	0.9	10	0.02	ND	280	15	0.32	6.3	110	1.2	10.0
Tammy, October 13	0.3	4.2		25	0.02				0.41	6.2			10.8
Tranquil, October 12	0.3	0.5	0.3	11	0.02	ND	150	14	0.21	5.3	44	1.1	8.9

*Laboratory analysis conducted by Alaska Department of Conservation laboratory, Douglas, Alaska

Table 6. Morphoedaphic Index of twelve lakes in southeast Alaska.

Lake	Specific Conductance (μ mho)	Residue Dissolved Calculated Sum (mg/1)	Surface Area (ha)	$\bar{x}$ Depth (m)	MEI*	Potential Yield** (kg/ha)
Finger	28	20***	347	10.7	1.87	1.32
Tammy	25	18***	134	10.0	1.80	1.30
Green	39	22	70	12.3	1.79	1.29
Klawak	39	24	1,177	17.7	1.36	1.13
Auke	28	20	46	19.0	1.05	0.99
Heckman	17	14	163	19.7	0.71	0.81
Spurt	16	14	107	22.2	0.63	0.77
Karta	26	16	508	27.6	0.58	0.74
De Boer	13	13	51	23.0	0.56	0.72
Patching	17	14	207	30.2	0.46	0.66
Blue	33	22	538	52.0	0.42	0.63
Osprey	20	14	109	60.0	0.23	0.46
Swan	20	16	208	91.4	0.18	0.41

*MEI = Morphoedaphic Index = $\frac{\text{Total Dissolved Solids (TDS)}}{\text{Mean Depth } (\bar{z})}$ (Ryder, 1965)

**Ryder (1965) described the equation $y \sim 2\sqrt{x}$ where y = yield in pounds per acre and mean depth ($\bar{z}$) was in feet. The metric expression (Ryder et al., 1974) is therefore $y \sim 0.966\sqrt{x}$ where yield is fish yield as kg/ha and x = MEI.

***Calculated as 0.70 x specific conductance in micromhos.

Table 7. Plankton composition, density (organisms per square meter), and weight (milligrams per square meter) as collected with No. 10 and No. 20 Nitex plankton nets, Finger Lake, 1976.

Date	June 9	June 28		July 20		August 12	
Depth of Tow (m)	40	46	46	29	32	26	37
Mesh Size	20	10	20	10	20	10	20
Copepoda							
Calanoida							
Diaptomus sp.	30,048	55,767	25,973	22,154	22,408	5,093	6,366
Epischura sp.	2,037	764	0	0	1,019	0	1,273
Cyclopoida	176,214	488,918	412,524	235,229	120,192	168,065	243,185
Nauplii	52,456	0	299,462	764	18,600	0	474,912
Cladocera							
Daphnia sp.	12,223	18,334	9,167	7,639	3,055	7,639	8,913
Bosmia sp.	13,242	27,501	13,751	12,223	3,056	20,372	20,372
Holopedium sp.	6,111	764	0	2,292	1,018	0	1,273
Rotatoria							
Kellicottia sp.	25,973	3,819	47,364	3,819	2,241	3,820	17,825
Miscellaneous		0	0	8,556	76,393	0	1,273
Diptera							
Culicidae larvae							
Chaoborus sp.	41	20	20	25	25	5	5
Chaoborus pupae	0	0	0	5	5	5	10
Dry Weight	488.9	649.9	529.7	287.7	300.0	273.0	243.9
Organic Weight	455.3	619.8	480.8	274.0	288.8	253.1	228.7
Ash Weight	33.6	30.0	48.9	13.8	11.2	19.1	15.3

Table 8. Plankton composition, density (organisms per square meter), and weight (milligrams per square meter) as collected with No. 10 and No. 20 Nitex plankton nets, Tammy Lake, 1976.

Date	June 15		July 8		July 28		August 18	
Depth of Tow (m)	31	32	28	30	23	23	30	30
Mesh Size	10	20	10	20	10	20	10	20
Copepoda								
Calanoida								
Epischura sp.	2,546	1,527	5,602	6,111	1,018	1,273		
Cyclopoida	3,412	8,658	16,297	19,353	11,713	21,644	49,910	4,940
Nauplii	509	715,043	6,111	1,604,263	256	352,683	6,875	53,984
Cladocera								
Daphnia sp.	20,371	18,843	9,167	3,056	764	1,273	509	509
Bosmia sp.	11,713	10,695	10,185	5,602	509	1,273	255	
Holopedium sp.	12,223	25,464	13,750	11,713				
Rotatoria								
Kellicottia sp.	509	13,750		13,750	509	16,551	764	10,695
Miscellaneous	509	6,875		4,584				
Diptera								
Culicidae larvae								
Chaoborus sp.	153	56	245	158	20	5	15	15
Dry Weight	380.1	260.2	477.2	488.4	55.5	101.9	57.5	32.6
Organic Weight	274.5	198.6	438.0	454.8	50.9	92.2	47.4	30.0
Ash Weight	37.0	61.6	39.2	36.6	4.6	97.7	10.2	2.5

Table 9. Plankton composition, density (organisms per square meter), and weight (milligrams per square meter) as collected with Nc. 10 and No. 20 Nitex plankton nets, Raven and Moss lakes, 1976.

	Raven Lake		Moss Lake	
Date	June 22		August 4	
Depth of Tow (m)	15	16.5	2	2
Mesh Size	10	20.0	10	20
Copepoda				
Calanoida				
Diaptomus sp.	2,291	2,291		
Epischura sp.	764	764	2,546	3,055
Cyclopoida	87,852	71,810		
Nauplii		48,127		
Cladocera				
Daphnia sp.	40,488	1,833	764	2,291
Bosmia sp.	61,878	50,419		763
Holopedium sp.	16,806	17,570		
Rotatoria				
Kellicottia sp.	2,292	4,583		
Miscellaneous		27,501		
Diptera				
Culicidae larvae				
Chaoborus sp.	183	71		
Chaoborus pupae	5			
Dry Weight	601.5	505.2	41.3	47.9
Organic Weight	546.5	461.9	35.1	39.7
Ash Weight	55.0	43.3	6.1	8.1

Table 10. Plankton composition, density (organisms per square meter), and weight (milligrams per square meter) as collected with No. 10 and No. 20 Nitex plankton nets, Osprey Lake, 1976.

Date	June 9		June 21		July 2		July 26	
Depth of Tow (m)	100	100	100	100	100	100	100	100
Mesh Size	10	20	10	20	10	20	10	20
Copepoda								
Calanoida								
Diaptomus sp.	14,769	20,626	25,719	19,098	54,494	22,918	40,743	29,538
Cyclopoida	7,130	7,639	7,639	5,602	10,185	4,583	3,565	5,092
Nauplii	22,408	24,191	5,092	3,820	1,018	1,018		2,546
Cladocera								
Daphnia sp.		254		254	1,018	509		
Bosmia sp.			254	764	5,602	3,055	8,657	5,092
Holopedium sp.		254	255	255	1,527		509	
Polyphemus sp.								
Rotatoria								
Kellicottia sp.	254	1,273		764		1,018		1,018
Keratella sp.		764		254				
Miscellaneous		3,565	254	5,856	16,297	57,549	5,092	255,154
Dry Weight	101.9	154.8	181.3	169.1	445.6	385.0	710.0	573.5
Organic Weight	90.1	126.8	169.6	153.8	424.7	359.0	679.4	527.1
Ash Weight	11.7	28.0	11.7	15.3	20.9	26.0	30.6	46.3

Table 10. (Cont.) Plankton composition, density (organisms per square meter), and weight (milligrams per square meter) as collected with No. 10 and No. 20 Nitex plankton nets, Osprey Lake, 1976.

Date	August 13		August 26		August 31		October 11	
Depth of Tow (m)	100	100	100	100	100	100	100	100
Mesh Size	10	20	10	20	10	20	10	20
Copepoda								
Calanoida								
Diaptomus sp.	18,502	8,912	25,973	15,024	35,395	30,557	14,260	5,092
Cyclopoida	5,434	2,801	6,111	4,329	5,347	2,378	2,545	1,527
Nauplii	1,186	1,528	2,801	6,111	509		509	16,042
Cladocera								
Daphnia sp.	1,018	1,273	5,092	7,384	5,602	2,887	1,528	6,875
Bosmia sp.	17,825	11,204	25,464	14,005	26,992	21,899	6,366	5,347
Holopedium sp.	8,826	1,782	8,403	8,912	7,385	3,223	8,148	3,310
Polyphemus sp.	168			255	256	341		
Rotatoria								
Kellicottia sp.	677	1,528	1,018	11,459		1,695	3,310	11,459
Keratella sp.		256				341		
Miscellaneous	1,186	484,844	70,027	213,901		3,055	30,302	146,420
Dry Weight	385.0	420.2	557.7	452.8	697.2	519.5	274.5	205.8
Organic Weight	358.0	369.2	530.7	426.8	651.4	494.5	254.6	184.4
Ash Weight	27.0	50.9	27.0	26.0	36.7	25.0	19.9	21.4

samples collected throughout the summer was averaged for each lake with available data. Average standing crop (organic weight in kg/ha) of No. 20 net plankton for 13 lakes in southeast Alaska are: Klawak, 41.9; Swan, 23.9; Osprey, 15.9; Blue, 15.8; Finger, 14.5; Auke, 12.0; Heckman, 12.0; De Boer, 10.7; Patching, 10.5; Tammy, 7.8; Spurt, 7.0; Redoubt, 4.1; and Green, 1.6.

Bottom Fauna:

Bottom fauna collected by dredging and screening benthic material are identified and enumerated in Table 11. Analysis of stream drift organisms from inlets to Finger Lake (Table 12), Tammy Lake (Table 13), Raven Lake (Table 14), and Sarkar Lake (Table 15) show a wide diversity of species. A list of insects collected by surber and grab sampling is presented in Table 16.

Fish:

The Sarkar system is open to anadromous fish and contains populations of coho, sockeye, pink, O. gorbuscha (Walbaum), and chum salmon, O. keta (Walbaum). Steelhead, Salmo gairdneri Richardson, and resident and sea-run cutthroat trout, S. clarki Richardson, and Dolly Varden, Salvelinus malma (Walbaum), are also found. No reliable estimates of salmon production are available for recent years.

A brief description and evaluation of streams is included here. For more complete information the reader is referred to the Catalog and Inventory files.

Northeast Inlet to Raven Lake

The area between the lake and the beaver pond is a ravine-like area, 3 to 10 feet wide, with a cobble-boulder bottom. The substrate has a heavy amount of aquatic vegetation. Several rearing coho salmon were seen here. The section above the beaver pond is 4 to 10 feet wide and 6 inches to 12 inches deep. This stream has spawning gravel and large stones and is well shaded by overhanging timber. Undercut banks and root cover are abundant. Coho salmon fry and fingerlings are abundant, indicating the importance of this stream for spawning and rearing. Logging should be kept out of the confines of this drainage, as logging would seriously damage this stream.

North Shore Inlet to Raven Lake

This stream is 3 to 3.5 miles long, but only the lower 1.5 miles were surveyed. In the section surveyed, two tributaries enter from the west. The entire stream has good spawning gravel with rubble and scattered rocks. The watershed terrain is rolling hills and muskeg.

The first half mile of stream is 30 to 50 feet wide with average depth of 1 foot. Velocity and discharge were 2.3 feet per second and 98 cubic feet per second (cfs) measured in late June. The lower 0.5 mile and last 0.25 mile had a 25:75 pool riffle ratio. The center section has

Table 11. Identification and enumeration (organisms/m^2) of benthic organisms from Finger, Moss, and Tammy lakes, 1976.

Lake	Finger	Moss	Tammy
Depth Range (m)	1.0-13.5	2.0-3.5	0.5-23.0
Number Samples	5	2	12
Nematoda			4
Oligochaeta	9	22	57
Hirudinea	17	22	14
Amphipoda	60		4
Gastropoda	413	215	22
Pelecypoda	52	387	115
Insecta			
Collembola			
Peduridae	26		
Odonata			
Lestidae	9		
Ephemeroptera			
Caenis sp.	9	22	
Coleoptera			
Chrysomelidae			
Donacia sp.		258	
Diptera			
Ceratopogonidae			
Polpomyia sp.			11
Chironomidae			
Chironomus sp.	189	22	
Diamesa sp.		22	
Dicrotendipes sp.	17		
Endochironomus sp.			97
Pentaneura sp.	34	43	
Polypedilum sp.	9		4
Procladius sp.	9		14

Table 12. Identification and enumeration of stream drift organisms, inlet to Finger Lake, 1976.

Date	June 8		June 30		July 21		August 13	
Net	1	3	1	2	1	2	1	2
Collembola								
Smynthuridae				1				
Lepidoptera								
Noctuidae			1					
Ephemeroptera								
Ameletus sp.		3	6	3	3			
Baetis bicaudatis	1	1	30	25				
B. intermedius	4		12	8				
B. tricaudatus			3					
Cinygmula sp.	2	4	4	4	1			
Epeorus longimanus	2	1	7	2				
Ephemerella sp.					1		1	1
Paraleptophlebia memoralis				1				
P. debilis					1		1	2
Siphlonurus occidentalis	1							
Plecoptera								
Alloperla sp.			1	7				
Leuctra augusta			2	2				
Capnia sp.	1							
Coleoptera								
Dytiscidae	2							
Hydrophilidae			3					
Staphylinidae				1				
Tenebrionidae			2	1				
Scolytidae								
Dendroctenus sp.				1				
Trichoptera								
Limnephilidae	8	6			1		1	
Rhyacophilidae								
Rhyacophila vibox	1							
Rhyacophila sp.								1
Diptera								
Chironomidae								
Diamesa sp.								1
Pentaneura sp.		5	1					
Polypedilum sp.	1		271	293				
Simuliidae	1	1						
Empididae	1							
Calliphoridae				1				
Dolichapodidae			1	1				
Tipulidae								
Dicranota sp.				2				

Table 13. Identification and enumeration of stream drift organisms, inlet to Tammy Lake, 1976.

Date	June 16		July 9		July 28		August 19	
Net	1	2	1	2	1	2	1	2
Collembola							1	
Ephemeroptera								
Ameletus sparsatus	4		6	7	4		9	7
Baetis intermedius	9	2	3	4			10	27
B. tricaudatus				3	4			9
Baetis sp.	13	5	3					
Cinygmula sp.				1				
Epeorus longimanus	2							
Ephemerella (Serratella) tibialis	2		2	2				
E. S. inermis	1							
E. grandis flavitincta		1			1			
Paraleptophlebia debilis			4	1	11	17	5	
P. heteronia	7		1					
Siphlonuris columbianus	1							
Plecoptera								
Alloperla sp.	1			2	2		1	
Leuctra augusta	8	1	1		21	4		1
Nemoura sp.								1
Coleoptera								
Dytiscidae	1							
Chrysomelidae	1							
Trichoptera								
Limnephilidae		2			2		5	19
Rhyacophilidae								
Rhyacophila sp.				1				
Diptera								
Chironomidae	1	1						
Chironomus sp.					4		1	
Pentaneura sp.	2		1		2	1		
Heterotrissocladius sp.							1	
Simuliidae	5							
Empididae	1							
Bibionidae	1							

Table 14. Identification and enumeration of stream drift organisms, inlet to Raven Lake, 1976.

Date	June 23	
Net	1	2
Hirudinea	1	
Aranea	1	2
Insecta		
Ephemeroptera		
Baetis tricaudatus		2
Paraleptophlebia debilis	16	16
Plecoptera		
Leuctra augusta	1	
Coleoptera		
Dytiscidae		1
Hydrophilidae		2
Trichoptera		
Limnephilidae		8
Psychomyiidae		
Polycentropus sp.		1
Diptera		
Chironomidae		
Pupae	8	6
Larvae	8	
Pentaneura sp.	3	3
Diamesa sp.		1
Micropsectra sp.		1
Tipulidae		2

Table 15. Identification and enumeration of stream drift organisms, inlet to Sarkar Lake, 1976.

Date	July 16		August 4	
Net	1	2	1	2
Ephemeroptera				
Ameletus sp.	4	1	7	
Baetis bicaudatus	1	2	39	
B. intermedius			4	
B. tricaudatus			1	2
Cinygmula sp.	24	8		
Epeorus albertae	2			
E. longimanus	1	1		
Ephemerella (Drunella) doddsi			1	
E. (Serratella) teresa	3			
E. S. tibialis	8	4	73	2
Paraleptophlebiidae				
Paraleptophlebia heteronia		1		
P. debilis	1			
P. memoralis	1			
Plecoptera				
Alloperla sp.	12			
Leuctra augusta	3	2		
Coleoptera				
Dytiscidae		1		
Trichoptera				
Limnephilidae	7	48		
Leptoceridae				
Decetis sp.		1		
Philopotamidae				
Dolophilus moestrus			1	
Rhyacophilidae				
Rhyacophila lobifera			1	
Diptera				
Chironomidae				
Pentaneura sp.			6	
Micropsectra sp.			1	
Tipulidae				
Tipula sp.		6		

Table 16. List of insects found in Surber samples and grab samples from inlets to Finger, Raven, Sarkar, and Tammy lakes, 1976.

Lake	Finger	Raven	Sarkar	Tammy
Ephemeroptera				
Ameletus sp.	X			X
Baetis bicaudatus				X
B. intermedius	X			X
B. tricaudatus	X		X	X
Cinygmula sp.	X		X	
Epeorus longimanus				X
Ephemerella grandis havineta				X
E. infrequens				X
E. (Serratella) inermis	X			
E. S. teresa				X
E. S. tibialis			X	X
Paraleptophlebia heteronea				X
P. debitis	X		X	X
P. memoralis	X		X	
Plecoptera				
Alloperla sp.	X			X
Leuctra augusta	X		X	X
Nemoura zapada	X		X	
Hesperoperla pacifica				X
Trichoptera				
Limnephilidae			X	X
Diptera				
Chironomidae				
Pentaneura sp.	X	X		X
Simuliidae				
Prosimulium sp.			X	
Rhagionidae				
Atherix sp.			X	

fewer pools. This is a very important spawning and rearing stream. This inlet with all of its tributary rearing areas should be protected from watershed alteration.

Outlet From Long Lake to Pond A

This section of outlet stream is bedrock and boulder for about 0.2 mile. The bottom of the creek is very slippery, making travel difficult. Walking time over this section is about a half hour.

Pond A

Pond A contains dark muskeg water with little shoreline vegetation. Minnow trap catches of rearing coho salmon were good in this pond.

Bedrock and Boulders Section

Immediately below pond A is a bedrock and boulder falls about 100 yards long leading to a small deep pond. Beyond that pond, another bedrock and boulder run leads to a large pond B. The distance between pond A and B is less than one-half mile.

Pond B

Pond B has shoreline lily pads and serves as a rearing area for salmon fry. The area from Pond B to the unnamed lake is bedrock and boulders about a half mile long.

Unnamed Lake (Jumping Fish or Middleman)

This lake has several extensive beds of lily pads. The lake is dark colored and has rocky and muddy shoreline areas. Several schools of fingerling salmon were seen near the surface, indicating its importance for rearing fish. This lake has two main inlets, one from Finger Lake and one from Raven Lake.

Northeast Inlet to Finger Lake

A thorough evaluation of this stream was not completed. The lower half mile which was surveyed had slow moving water. The first 500 yards are slow and deep. The next 200 yards was 10 to 15 feet wide and 6 inches to 12 inches deep. This section has medium-sized rocks with little gravel. Above this, a deep 600 yard section runs through a grassy meadow. The section surveyed had little spawning potential, but several rearing fish were seen. This creek originates in two muskeg ponds about 2 miles upstream, so it may be an important rearing area.

East Shore Inlet to Finger Lake

The east shore tributary is an important spawning and rearing stream for coho salmon. The lower 400 yards is 2 to 6 feet deep. Average discharge in mid-August was 11 cfs. This stream has good spawning gravel, shade from big timber, and escape cover in the form of undercut banks, logs,

and rocks. The stream originates about 1.25 miles upstream. Sockeye salmon were concentrated off the mouth of this inlet. Minnow traps set in the creek caught steelhead and cutthroat trout, Dolly Varden, cottids, and stickleback, Gasterosteus aculeatus (Linnaeus).

Southeast Inlet to Finger Lake

This stream (Figure 2) is an important spawning and rearing stream. The lower 200 yards has deep, slow moving water, 10 to 12 feet wide and 2 to 3 feet deep. The upper portion of the creek is 6 to 18 inches deep with pools, shade from mature hemlock, and cutbanks for cover. From 0.5 to 0.75 miles above the mouth of the stream, the stream gradient gets steeper with less cover and more medium-sized gravel. Discharge from the stream is about 5 cfs. Banks of this stream would be very subject to damage from logging.

Outlet From Finger Lake to Pond C

The outlet from Finger Lake has mainly bedrock and boulder bottom. This section is about 0.6 mile long with alternating stretches of deep, slow moving water and rapids. There are two sets of rocky rapids with 2- to 4-foot falls. Average width was 20 feet with depth varying from 6 inches to 6 feet.

Pond C

This pond has lily pads along one shoreline and the water is dark. The bank is easily walked. Bear sign was abundant in the area.

Stream Between Pond C and Unnamed Lake

This portion of creek is nearly 1 mile long. Most of the substrate is large rock. The stream has fast water and small rapids. Average width is 15 feet with depth of 6 to 18 inches. The last 100 yards was slow, shallow water grown in with lily pads.

Stream From Unnamed Lake to Sarkar Lake

The main inlet to Sarkar Lake flows about 0.5 mile from unnamed lake. The first 50 yards from unnamed lake is 1 to 5 feet deep and 50 feet wide with large mossy boulders. This is followed by 200 yards of slow, deep water, 100 yards of rocky rapids, and another 100 yards of slow, deep water. There is a 6- to 8-foot angled falls about 400 yards above Sarkar Lake. Coho and sockeye salmon easily get over the falls. Below the falls there is about 200 yards of fast water with bedrock and boulder substrate. This is followed by 150 yards of slow moving water flowing into Sarkar Lake. Mean flow in late June was about 22 cfs. Pink salmon spawn in the lower section of this stream.

Inlet to Tammy Lake

The main inlet to Tammy Lake is a large network of tributaries having several miles of stream. Only the lower section was surveyed. Discharge

varied from 3 to 112 cfs during the study period. The width ranges from 7 to 50 feet with an average depth of about 2 feet. The bottom is interspersed gravel, bedrock, and rubble. The bank cover consists of overhanging cedar, ferns, devils clubs, etc. This is an important cutthroat trout, coho salmon, and Dolly Varden rearing stream.

Outlet From Tammy Lake to Sarkar Lake

The upper section of this stream is about 0.75 mile from Tammy Lake to a waterfall. The stream alters between slow, deep slough areas and swift water sections. Stream width varies between 15 and 35 feet with an average depth in swift sections of about 1 foot. The stream bottom is mostly bedrock, boulder, or slab rock with few gravel or rubble areas. The banks are heavily shaded with cedar and hemlock.

A major waterfalls about 0.75 mile downstream descends about 20 feet over several spills. Five minnow traps in quiet water captured over 150 rearing coho salmon, while two traps set in swift water captured six rearing steelhead trout.

The lower 0.5 mile section of the outlet is similar to the upper section with alternating quiet water, riffles, etc. Rearing coho salmon, steelhead and cutthroat trout were captured in this section.

Inlet to Moss Lake

Approximately 0.5 mile of the inlet was surveyed. This stream is 8 to 10 feet wide and 6 to 24 inches deep. There are several old beaver dams which provide excellent rearing for coho salmon and cutthroat trout. Substrate is mainly fine sand and silt.

Outlet From Moss Lake to Sarkar Lake

The south inlet to Sarkar Lake is a slow velocity muskeg stream flowing about 0.8 mile from Moss Lake. Below the east fork tributary it is 12 to 15 feet wide and 6 to 24 inches deep. The streambed is primarily sand and gravel but does have some bedrock. Above the entrance of the tributary the main stream meanders through a tall grass meadow. The stream is 10 to 15 feet wide and 1 to 3 feet deep with grassy bottom. Adult and rearing cutthroat trout and rearing coho salmon were seen in this section.

The east fork was 12 to 15 feet wide in the lower reaches and 6 to 8 feet deep with a few pools to 2 feet deep. A bedrock falls 1 to 3 feet high and rapids 100 yards long with log jam were found about 0.25 mile upstream. Above the falls the stream was flatter with bedrock, boulders, and some gravel. Coho salmon fry were seen there. The stream may get better above the half mile surveyed.

Rearing and resident fish were sampled by gill net and minnow traps during the summer of 1976. A summary of catches by number and species is shown for all gill net and minnow trap sampling in Figure 14. Mean length and weight of cutthroat trout by lake and age group is presented

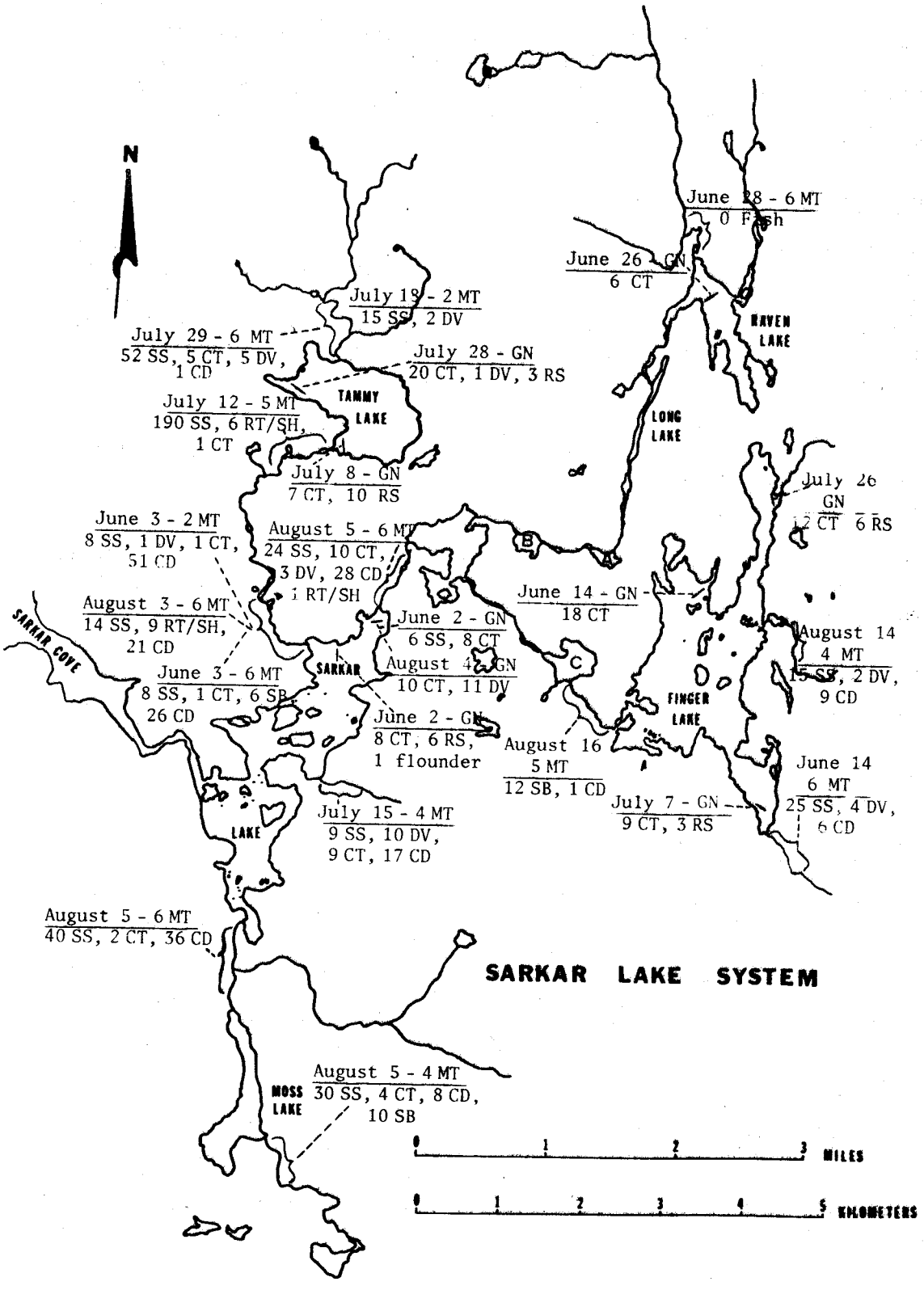


Figure 14. Summary of minnow trap (MT) and gill net (GN) catches, Sarkar lakes system, 1976.

in Table 17. Mean length of Dolly Varden by age group is shown in Table 18. Condition factors of cutthroat trout and Dolly Varden are shown by lake in Table 19. Condition factors of resident and post-spawning trout were low, usually between 0.80 and 0.95. Condition factor of fall immigrant sea-run cutthroat trout was 1.25.

Length-weight relationships of cutthroat trout is identical in Raven and Finger lakes (Figure 15). Cutthroat trout in Tammy Lake weighed more at any given length, as shown by the curve on Figure 15. Two length-weight relationships were calculated for cutthroat trout in Sarkar Lake. The relationship for resident and that for sea-run fish varied widely (Figure 16). The length-weight relationship of Dolly Varden in Tammy Lake is shown in Figure 17.

Stomach contents of cutthroat trout from Finger, Tammy, Raven, and Sarkar lakes were examined and enumerated in Tables 20 through 23, respectively. Fish remains were by far the most abundant food item, occurring in 44% to 72% of stomachs examined. A positive identification of which species was eaten most frequently was not possible, but stickleback remains were common. Other organisms were eaten as availability allowed.

Recreational Analysis

The highlights of the Sarkar system are the mammalian and avian fauna and the tributary streams entering the various lakes. There is much more wildlife activity in the Sarkar system than anywhere in southeast Alaska analyzed to date. The small streams and their associated riparian communities were inspiringly beautiful with impressive red and yellow cedar, western hemlock, Sitka spruce, and lush fern understory. While walking a stream you would often be following deer, bear, and occasionally wolf tracks. A list of birds and mammals encountered is shown in Table 24.

The interest and use of the Sarkar system will vary with season, depending upon the presence of salmon and hunting openings. Owing to the access via road and boat, the development of Sarkar Lake is basic to the recreational utilization of the system. Facilities could include a saltwater boat dock, a trail to Sarkar Cove, skiffs, a boat ramp from the road to the lagoon, and possibly a picnic and camping area along the road (Figure 18).

Because of the multiple access to the lagoon and hence added developmental features, a potential for "recreational congestion" or high land use pressure exists. It is important to develop the system overall such that the headwater lakes of the Sarkar system have a more limited access. A person at Finger, Raven, or Tammy lake should be just as likely to see a deer, otter, or bear as another human being. The point is not to overdevelop in a manner that would destroy what the Sarkar offers best.

The headwater lakes, Finger, Raven, and Long lakes, have a good canoeing area given one or two short trails for portaging. Raven Lake especially has nice slough-like channels at both the inlet and outlet. Some caution should be used while canoeing in Finger Lake, as strong southeast winds can create very rough water out in the main basin.

Table 17. Mean length and weight of cutthroat trout by age class, Panger, Raven, Sarkar, and Tammy lakes, 1976.

Age	Number	X Length	Range	Standard Deviation	X Weight	Range	Standard Deviation
				Panger Lake			
4	2	217.5	180-225	53.00	122.0	100-145	31.80
5	12	248.8	205-272	17.70	146.0	125-172	15.90
6	22	259.0	214-289	12.60	153.0	103-198	12.90
7	12	276.0	242-317	16.30	167.0	108-260	31.30
8	1	423.0			590.0		
9	1	390.0			510.0		
				Raven Lake			
3	1	128.0			24.0		
4	2	208.2	207-210	1.64	76.0	72- 80	5.66
5	3	261.3	235-290	27.57	164.6	115-220	52.73
6	12	284.5	250-305	28.34	164.1	110-240	45.80
7	1	318.0			265.0		
8	1	296.0			220.0		
9	1	320.0			215.0		
				Sarkar Lake			
2	1	121.0			14.0		
4	4	247.8	141-305	74.1	197.5	115-295	75.70
5	9	244.0	222-265	18.2	141.6	130-150	18.60
6	10	255.0	135-360	62.1	195.0	65-450	117.90
7	1	347.0	275-390	54.8	443.0	300-500	96.59
				Tammy Lake			
3	1	120.0			16.0		
4	1	227.0			122.0		
5	11	264.9	240-295	19.4	178.5	120-250	43.02
6	15	282.8	220-312	29.3	181.3	113-300	51.60
7	13	299.7	235-380	43.2	263.5	120-420	87.70
8	9	328.0	285-395	44.3	305.3	200-500	101.90
9	2	305.5	301-310	6.3	258.5	222-295	51.62

Table 18. Mean length of Dolly Varden by age group, Tammy and Sarkar lakes, 1976.

Age	Number	$\bar{x}$ Length	Range	Standard Deviation	$\bar{x}$ Weight	Range	Standard Deviation
				Tammy Lake			
4	2	273.0	265-281	11.30	187.5	185-190	3.54
5	2	294.5	290-299	6.30	224.0	218-230	8.49
6	3	250.3	235-266	15.5	154.0	130-177	23.50
7	5	270.8	241-306	26.4	173.0	135-220	38.10
8	2	296.0	275-317	29.7	272.5	195-350	109.60
9	2	411.5	405-418	9.19	515.0	505-525	14.10
				Sarkar Lake			
3	3	227.0	176-289	57.40			
4	5	244.0	226-282	23.40			
5	2	285.0	275-296	14.80			

Table 19. Condition factors (K)* of cutthroat trout and Dolly Varden from Finger, Raven, Sarkar, and Tammy lakes, 1976.

Lake and Species	Number	Condition Factor (K)* $\bar{x}$	Range	Standard Deviation
Finger,				
Cutthroat Trout	48	0.87	0.68-1.05	0.08
Tammy,				
Cutthroat Trout	50	0.96	0.58-1.16	0.12
Dolly Varden	17	0.91	0.58-1.10	0.13
Raven,				
Cutthroat Trout	20	0.88	0.66-1.14	0.09
Sarkar,				
Cutthroat Trout (Spring)	12	0.82	0.79-0.87	0.05
Cutthroat Trout (Fall)	10	1.25	1.04-1.54	0.15

*$K = \frac{100 \times \text{Weight (gm)}}{\text{Fork Length (cm)}^3}$

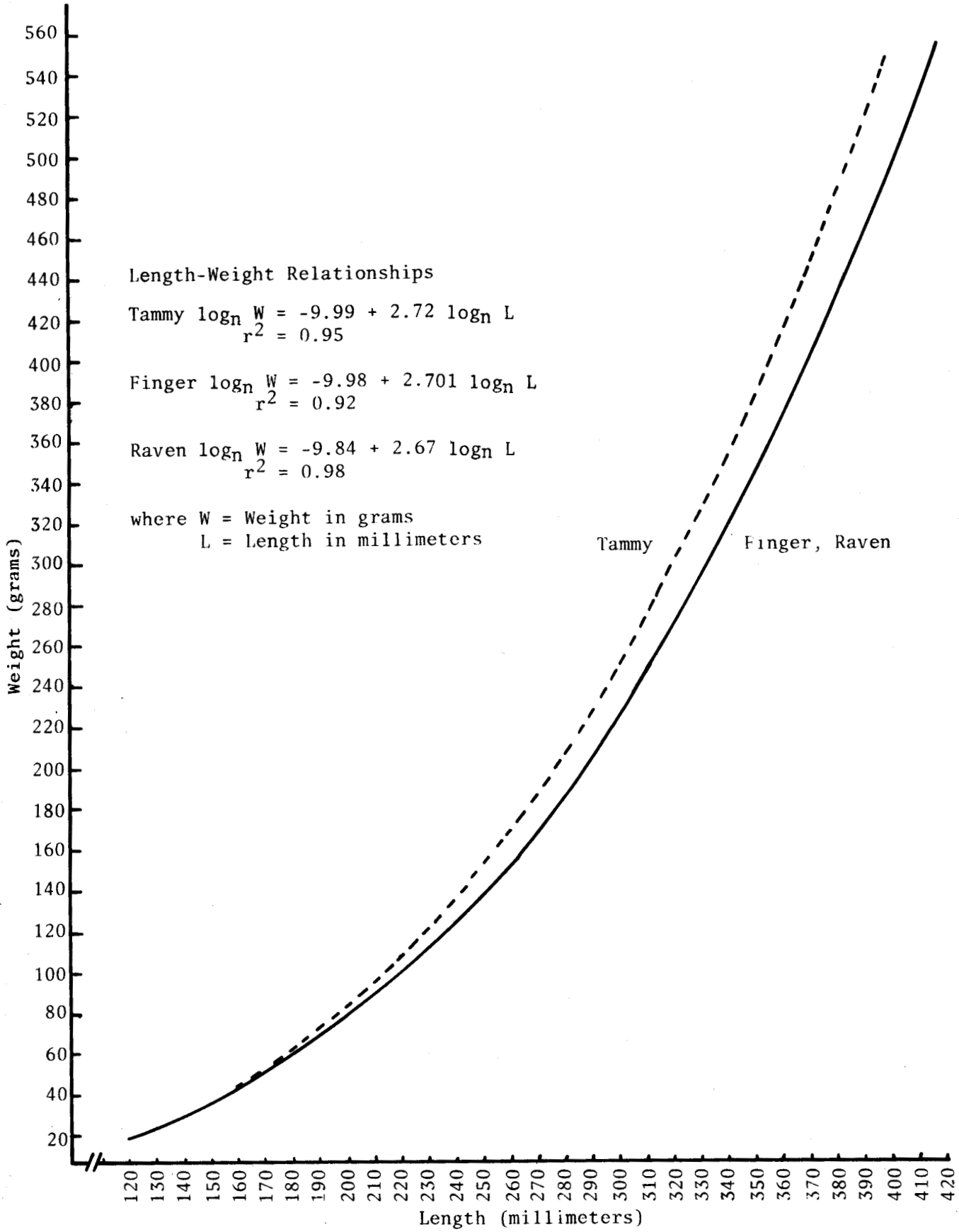


Figure 15. Length-weight relationships of cutthroat trout, Tammy, Finger, and Raven lakes, 1976.

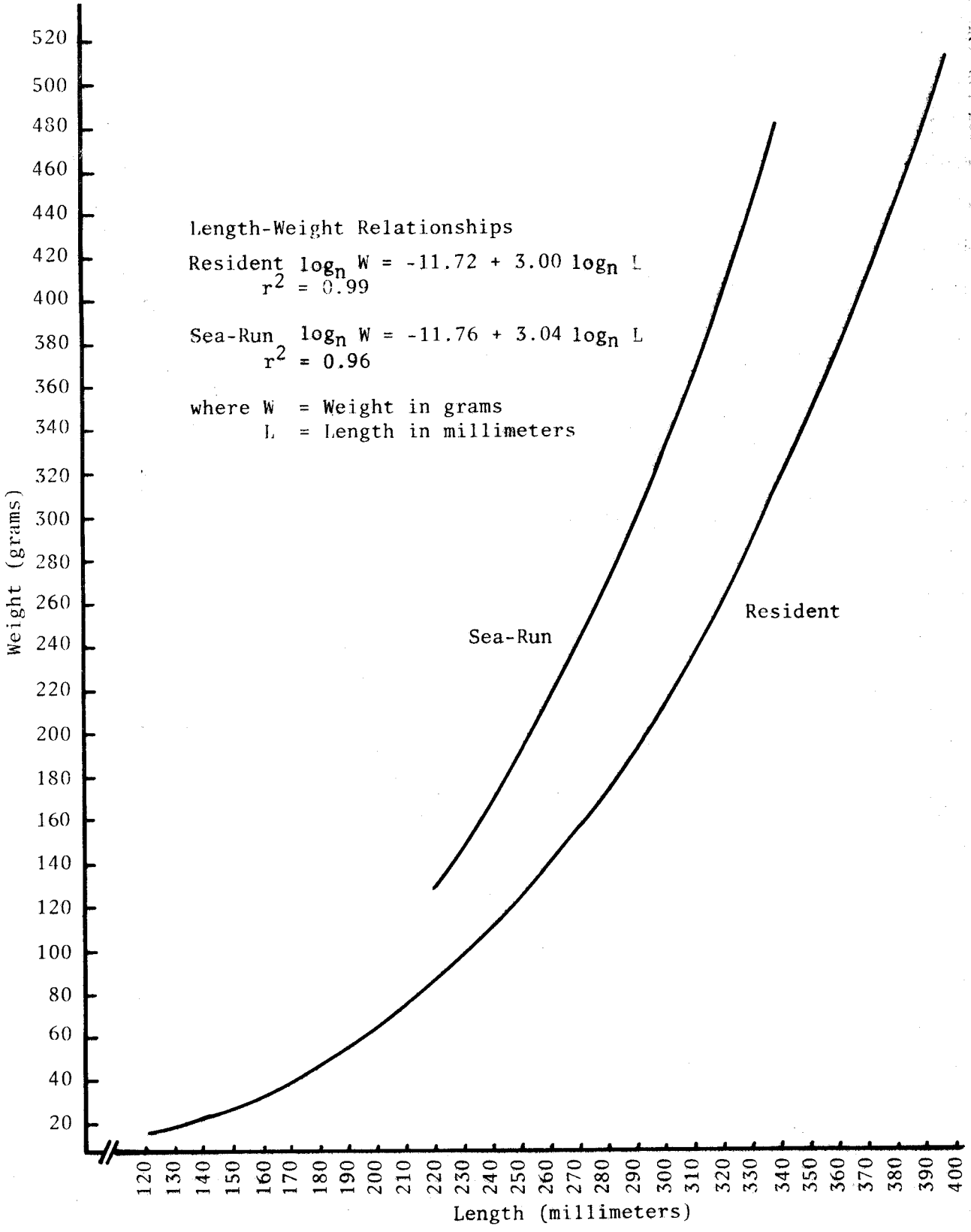


Figure 16. Length-weight relationship of resident and sea-run cutthroat trout, Sarkar Lake, 1976.

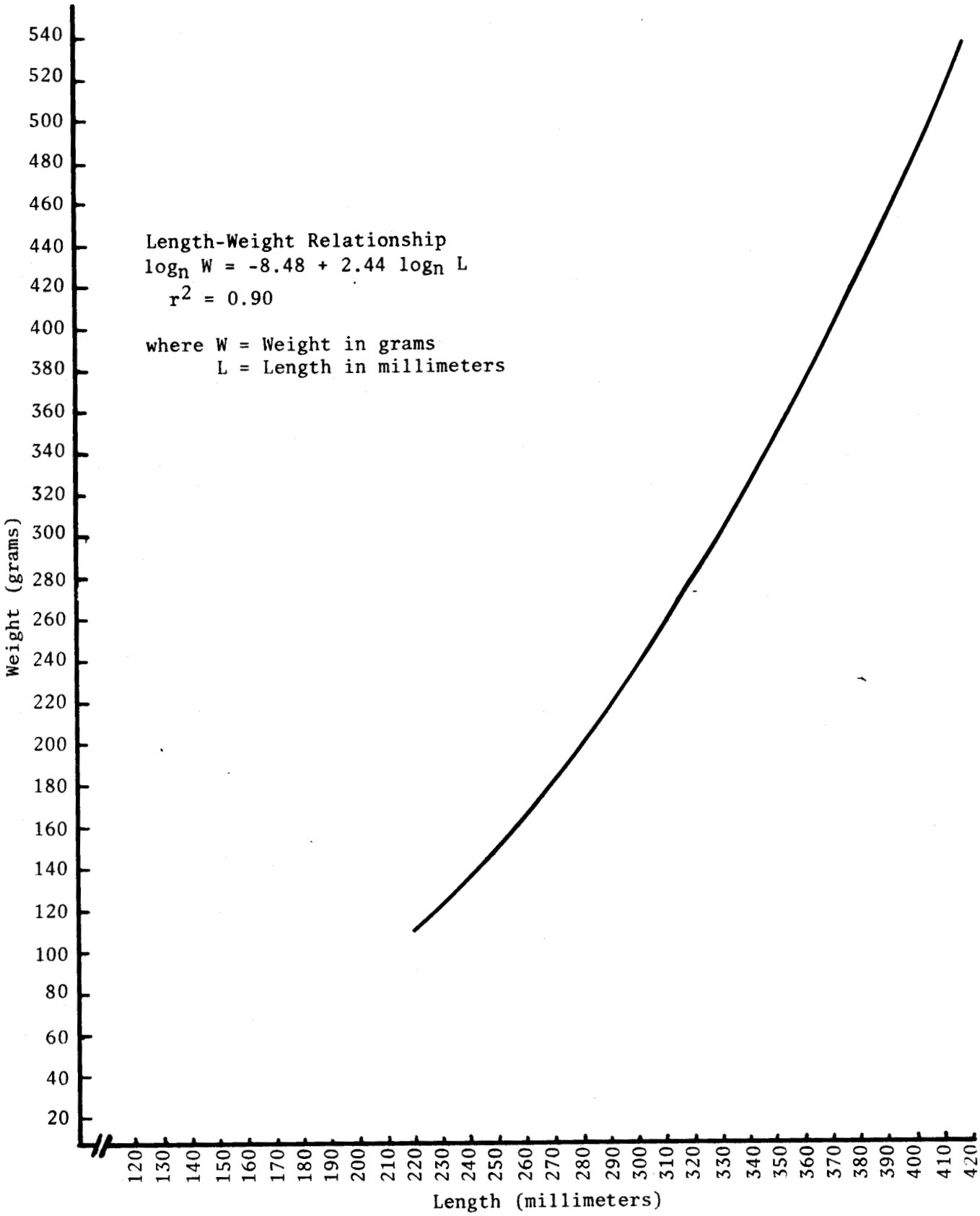


Figure 17. Length-weight relationship of Dolly Varden, Tammy Lake, 1976.

Table 20. Stomach content analysis from cutthroat trout, Finger Lake, 1976.

Fish Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	
Length (mm)	260	390	260	242	265	250	275	270	240	250	317	247	266	252	225	180	262	272	269	281	256	275	255	267	232	275	266	275	275	275	310	245	410	284	
Sex	F	F	F	M	F	M	F	F	F	M	F	F	F	F	F	M	F	M	F	F	F	M	M	F	F	M	F	F	M	F	F	M	F	M	Percent Occurrence
Arachnoidia				1																															3
Gastropoda																		3																	3
Ephemeroptera										2					1																				
Ameletus sp.										2					1																				6
																																			6
Coleoptera				5	1					1				3							2					1				1					
Elateridae																					2														18
																																			3
Trichoptera												2		1	4	2			11			2	2		3	1						1			
Limnephilidae												2		1	3	2			11			1			3	1									29
Rhyacophilidae																						1	2													22
																																			6
Diptera				6				1							1	1			11		16			1					1	56			10	24	
Ceratopogonidae																																			32
Stilobezzia sp.																1					16									54					8
Chironomidae								1											1																3
Pentaneuri sp.																																			3
Culicidae																			10														10	24	8
Chaoborus sp.																																			
Odonata					1																														3
Miscellaneous																																			
Fish Remains	X	X	X		X	X	X	X	X	X							X			X	X	X	X	X	X		X	X		X	X				56
Shrew																																			3

Table 21. Stomach content analysis from cutthroat trout, Tammy Lake, 1976.

Fish Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Length (mm)	285	240	240	295	335	309	295	263	275	228	235	290	230	250	312	295	345	310	305	217	265	395	290
Sex	F	F	M	F	F	M	M	M	F	F	M	M	F	M	F	M	F	M	F	F	M	M	M
Arachnoidia																							
Hirudinea																							
Ephemeroptera																							
Ephemerella grandis flavitincta							1																
Plecoptera																							
Alloperla sp.																							
Coleoptera	4	1	30	1	2	5	1	1	1	24													
Cerambycidae	1																						
Elateridae	2		15						1	24													
Staphylinidae	1	1	15																				
Trichoptera	1	1					3	2															
Hydropsychidae																							
Cheumatopsyche sp.		1																					
Leptoceridae								1															
Limnephilidae	1																						
Phryganeidae																							
Rhyacophilidae																							
Rhyacophila sp.								1															
Diptera	6	33	115	1	1	4		1			2			15	2								
Bibionidae	1	2	45																				
Ceratopogonidae																							
Stilobezzia sp.		26																					
Chironomidae	5	4	70								1												
Empididae		1																					
Tipulidae														15									
Hymenoptera																							
Odonata					1																		
Miscellaneous																							
Fish Remains		X		X	X	X	X	X	X				X		X	X	X	X	X	X	X	X	X

Table 21. (Cont.) Stomach content analysis from cutthroat trout, Tammy Lake, 1976.

Fish Number	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	
Length (mm)	300	380	220	335	285	265	338	263	270	255	272	120	227	228	247	228	301	267	295	267	
Sex	F	F	F	F	M	M	M	M	M	F	F	F	F	M	M	M	F	M	F	M	Percent Occurrence
Arachnoidia																		2			2
Hirudinea					1																2
Ephemeroptera																					
Ephemerella grandis flavitincta																					2
Plecoptera																	1				2
Alloperla sp.																	1				2
Coleoptera																	1	1			28
Cerambycidae																					2
Elateridae																					9
Staphylinidae																		1			9
Trichoptera					1												4	1	1	4	21
Hydropsychidae																					
Cheumatopsyche sp.																					2
Leptoceridae																				3	5
Limnephilidae																	1				5
Phryganeidae																		1			2
Rhyacophilidae					1																2
Rhyacophila sp.																	3				5
Diptera					3												7		3		30
Bibionidae																					7
Ceratopogonidae					3																2
Stilobezzia sp.																					2
Chironomidae																			3		12
Empididae																					2
Tipulidae																		7			5
Hymenoptera																		1			2
Odonata														1							7
Miscellaneous																					
Fish Remains	X	X	X	X	X	X	X	X	X		X	X	X		X	X					72

Table 22. Stomach content analysis from cutthroat trout, Raven Lake, 1976.

Fish Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Length (mm)	290	245	285	235	207	257	320	282	210	235	230	231	305	210	128	271	
Sex	F	F	M	M	F	F	F	M	F	M	M	F	M	F	M	F	Percent Occurrence
Gastropoda								1									6
Coleoptera								10				1	1		1		25
Staphylinidae															1		6
Trichoptera	1							7		1	4	19			3		38
Hydrospsychidae										1							6
Cheumatopsyche sp.										1							6
Limnephilidae								5			4	19			3		25
Rhyacophilidae	1							2									13
Rhyacophila sp.	1							2									13
Diptera							95	8		2			12		5		31
Lepidoptera							1										6
Miscellaneous																	
Fish Remains	X		X		X				X				X		X	X	44
Shrew		X															6

Table 23. Stomach contents from cutthroat trout, Sarkar Lake, 1976.

Fish Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Length (mm)	390	264	141	258	222	255	240	224	360	198	261	290	390	265	265	135	252	121	
Sex	F	M	M	F	F	M	F	M	F	M	F	M	F	F	M	F	M	F	Percent Occurrence
Amphipoda				2															6
Isopoda (Marine)				1						2		1							17
Ephemeroptera		3								1									11
Baetis sp.		2																	6
Cinygmula sp.		1																	6
Epeorus longimanus										1									6
Plecoptera		9	19							2									17
Alloperla sp.		9	19							2									17
Coleoptera			1	6								1							17
Elateridae				5								1							11
Chrysomilidae				1															6
Trichoptera		1	1							2		1						12	28
Limnephilidae			1							2								12	18
Diptera																	1		6
Miscellaneous																			
Fish Remains	X				X	X	X	X			X	X		X	X				50

Table 24. List of birds and mammals encountered on the Sarkar lakes system, 1976.

Birds	Mammals
Bald Eagle	Beaver
Belted Kingfisher	Black Bear
Canada Goose	Black-Tail Deer
Cedar Waxwing	Deer Mouse
Chestnut-Backed Chickadee	Harbor Seal
Common Loon	Land Otter
Common Merganser	Marten
Common Raven	Mink
Glaucous-Winged Gull	Wolf
Hermit Thrush	
Junco	
Marbled Murrelet	
Mew Gull	
Northwestern Crow	
Rufous Hummingbird	
Song Sparrow	
Spotted Sandpiper	
Steller's Jay	
Tree Swallow	
Trumpeter Swan	
Varied Thrush	
Water Ouzel	
Western Flycatcher	
Winter Wren	
Yellow-Bellied Sapsucker	

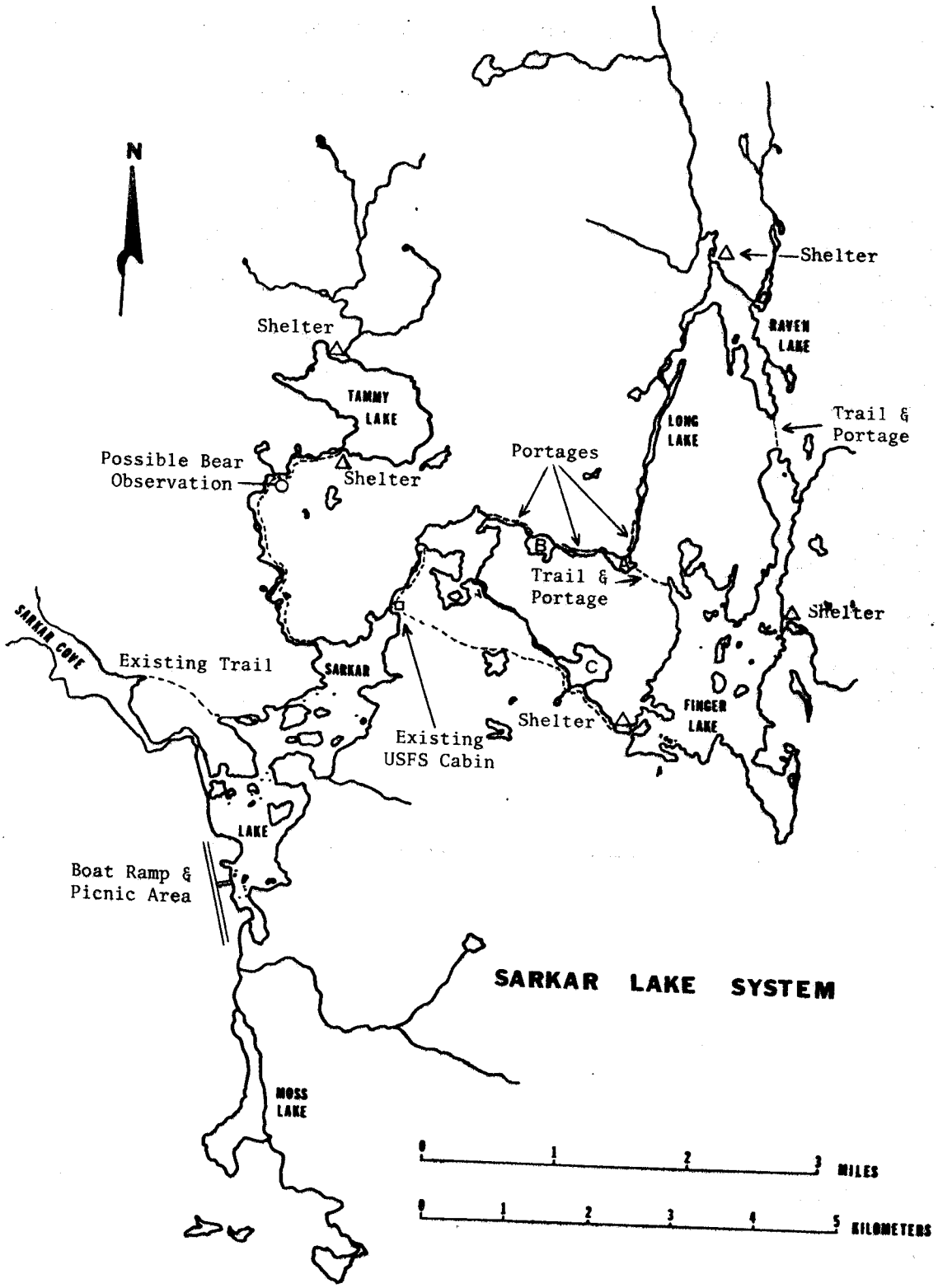


Figure 18. Existing and potential recreational facilities for Sarkar system.

Some trails should be constructed or cleared along certain major drainage streams so these waters could be more easily fished and to allow interlake travel on foot. Some type of shelters or campsites should be established.

Sarkar Lake:

Sarkar Lake, actually a brackish lagoon, is the lowest lake of the Sarkar complex. There is a freshwater lens on the surface, but the majority of Sarkar Lake is salt water. The surrounding terrain consists of low, rolling hills forested with Sitka spruce, western hemlock, yellow and red cedar, and lodgepole pine.

At high tide this lagoon may be entered with a small skiff from Sarkar Cove (Figure 18). At low tide three sets of rapids are exposed at the outlet, making passage difficult and unsafe. The surface elevation with respect to shore does not change dramatically with the tide. Sarkar Lake has a meandering shoreline and numerous islands, making navigation confusing at times.

Access to Sarkar Lake is primarily via floatplane from Ketchikan, Wrangell, or Petersburg. Air time from Petersburg is approximately 35 minutes. Sarkar Lake will become more heavily utilized in the near future as vehicular traffic increases throughout the Prince of Wales road system. The M.V. Chilkat based out of Ketchikan will soon be replaced with a larger ferry comparable to the M.V. La Conte. This will allow a greater influx of cars and boats to the roadway and into the recreational areas of the island. The logging road is currently along the south shore of Sarkar Lake, so canoes could easily be unloaded into the lake.

There is an old trail leading from the east shore of Sarkar Cove to the west shore of Sarkar Lake. It takes about 30 to 45 minutes to hike this trail. At one time there was a U.S. Forest Service skiff moored at the head of this trail; it is no longer present. A canoe or skiff should be made available for people who walk in from Sarkar Cove. A canoe might be more favorable than a skiff, as it would be impractical to carry in a motor; and Sarkar Lake is large enough so that considerable rowing would be necessary. The diversity and abundance of wildlife in the Sarkar Lake area would make a canoe trip very enjoyable.

There is a U.S. Forest Service cabin located on the east side of the north shore inlet. It has a woodburning stove and bunks for four adults. The lower bunks are wide and could sleep two children comfortably. There is an outhouse, a garbage dump, and a skiff and oars. The cabin construction does not allow for much natural light to enter, making a safe and reliable artificial light source desirable.

The cabin is used mostly when salmon are moving up through the lake complex. Sockeye salmon enter Sarkar Lake in early June, and coho salmon begin showing in mid-August. Pink and chum salmon are also in the lake system. Other species include steelhead and cutthroat trout, Dolly Varden, and numerous saltwater fishes.

Sarkar Creek, the main inlet to Sarkar Lake, drains a large portion of the Sarkar complex. It enters the north shore of Sarkar Lake beside the

U.S. Forest Service cabin. A well-used trail lies along the east shore of the stream, originating at the cabin. Approximately 0.1 mile upstream is a 6- to 8-foot slanted waterfall with a popular fishing hole at its base. Throughout the summer bald eagles and belted kingfishers are commonly seen near this inlet.

Mammalian wildlife are abundant in and around Sarkar Lake. Marten are frequently seen near the cabin. Mink, otter, and black bear are occasionally seen especially near the outlet and harbor seal patrol the lagoon. One location, an east shore cove with a small inlet, seems to be a favorite haunt. We saw 20 or more harbor seals hauled out on rocks and logs just north of this inlet. Several black bear were spotted at the outlet, and bear spoor was observed along all inlets to Sarkar Lake.

Birds commonly heard include hermit thrushes, western flycatchers, chestnut-backed chickadees, winter wrens, common ravens, varied thrushes, and juncos. Yellow-bellied sapsuckers are conspicuous in early summer. There are nesting mergansers and nesting Canada geese. Common loons, bald eagles, and belted kingfishers are also very common birds and greatly enhance the outdoor experience of Sarkar Lake.

Fishing opportunity varies with the season. Four species of salmon, steelhead and cutthroat trout, and Dolly Varden offer a wide range of opportunity.

Tammy Lake:

Tammy Lake is separated from the major Sarkar drainage system as an isolated lake to the north of Sarkar Lake. Tammy outlet creek empties into the northwest shore of Sarkar Lake. Tammy is an anadromous lake. Fish species present include steelhead and cutthroat trout, Dolly Varden, and sockeye and coho salmon. Ground relief around the lake periphery is low except for a 1,500-foot knoll to the northeast. One gets the impression of being in a caldera, as there is open sky in most directions.

This relatively small, punch-bowl shaped lake is readily accessible by floatplane. There are presently no trails or shelters at this lake, so it is strictly a tenting trip. The inlet delta, north shore, is a good place to camp during normal lake levels; but this site can flood when the lake level rises. The east and southeast shore offer better camping grounds. Ground level here is 4 to 6 feet above the lake, flat, and well drained. This area is matted with cranberry, Labrador tea, and scattered with relatively sparse cedar. There are no inlets in this vicinity, but the lake water is quite drinkable.

Common loons are seen on the lake during the summer, and their haunting calls reverberate throughout the basin. The loons at Tammy Lake are a real highlight. They are curious and seem to be constantly watching the human activity. Bald eagles are common when salmon enter the system. Chestnut-backed chickadees have been seen nesting in dying alders near the inlet. Other birds which are seen with regularity are belted kingfishers, common ravens, and water ouzles. Mammalian wildlife include deer, marten, mink, otter, black bear, and beaver.

The inlet stream appears to be a major rearing area for coho salmon fry. The water level of this stream is highly variable. Except for extreme high water this creek is easily waded with hip boots. The outlet creek is a fairly rugged hike with a lot of brush to fight in places. About 0.75 mile downstream there is an impressive waterfall. When we hiked to these falls, we actually saw no bears but saw abundant bear sign and found many bald eagle feathers. Bears and bald eagles congregate here when fish are concentrated below these falls. If a trail system was established throughout the Sarkar system, a trail to these falls and the construction of some type of bear observatory might be considered.

There is an excellent cutthroat trout fishery at the main inlet of Tammy Lake. Dolly Varden are catchable especially during late August and September when these fall spawners are gathering off the inlets. There is fair fishing for cutthroat trout in a small outlet lagoon about 80 to 100 m from the lake. Nothing is really known about the sport fishing below this point.

Finger Lake:

Finger Lake, the largest lake in the Sarkar system, stretches nearly 3 miles in length and is nearly 1 mile wide at the widest part. The lake has several narrow basins and several islands in the larger central basin, making it a rather interesting and scenic part of the Sarkar complex. Fish species present include cutthroat trout, Dolly Varden, and during late summer and fall, sockeye and coho salmon.

This lake is almost always accessible by floatplane. There are no trails, shelters, or cabins. Some type of watercraft should be taken in for mobility. The shoreline is heavily timbered, and the ground is fairly wet. Campsites are locatable, but you have to search them out. There are a few campsites along the east shore, just south of the cove fed by the mideast shore inlet.

At the mouth of the mideast shore inlet is a small ($\sim$1 acre) cove tucked away from the main lake basin. One evening was spent there, paddling around in the raft. Three beaver and one brood of ducks were seen. Sockeye salmon were jumping and cruising back and forth off the inlet mouth. This was a most beautiful and peaceful scene. The two inlets entering the southeast cove and the mideast shore are very scenic and are easily walked with hip boots. Both of these streams appear to be good spawning and rearing areas for salmonids.

Common loons, common mergansers, and Canada geese nest at Finger Lake. A mew gull nest was spotted on a small island in the southwestern part of the lake, close to the outlet cove. On a subsequent trip to Finger Lake the mew gull eggs were found destroyed.

Wolf and deer tracks were seen in the outlet area of Finger Lake. An interesting encounter with a wolf at this lake was described by Mark Schwan as follows:

> On July 20, while monitoring in the raft in the southeastern basin (most southerly part of lake), we heard and then spotted one wolf

barking at us from shore. We approached to within 50 to 60 yards, stopped the motor, and observed the wolf. It was pacing back and forth along the shoreline, after which it barked a few more times and then sat down. Then the wolf began to howl, and we howled back.

For the next 5 or 6 minutes we had a "howling contest" with this animal. When the wolf howled, the sound echoed through the entire southern lake basin. After a while the wolf walked up into the woods and disappeared. Not long ago I was talking with a friend who spent two summers observing wolves in Alaska; and he said the animal's behavior was indicative of a disturbed state, most likely implying that we were very close to a wolf den.

Other wildlife seen in the Finger Lake area included a large black bear swimming across a small lake downstream.

From the outlet of Finger Lake it takes about 30 minutes of steady walking to reach the next lake downstream. The walk is not difficult; but because of dense brush along shore in places, the going is slow and time can be saved by wading the stream. This stretch of river looked as if it might be suited for fly-fishing, but no sport fishing of any kind was conducted. The majority of this portion of stream is shallow, swift water with cobble, boulder, and bedrock bottom. Near the lake downstream, the stream bottom has more gravel.

Sport fishing efforts at Finger Lake were not very successful, but only spin casting gear was tried. Several 10-inch cutthroat trout were caught near the outlet.

Raven Lake:

Raven Lake, one of the headwater lakes in the Sarkar system, is a small, picturesque, and most pleasant part of this watershed. Weather conditions are critical to the accessibility of Raven Lake via airplane. Because of its small size, it is not possible to land a plane safely when winds are blowing across the lake.

There are no shelters or cabins at this lake. The shoreline is heavily wooded, and good campsites are not abundant. Campsites could be cleared or shelters constructed as an improvement to the recreational potential of Raven Lake.

Canada geese and one adult trumpeter swan were seen. The swan sighting was extremely exciting, as a young swan, most likely a trumpeter, was seen the following day. This is perhaps a first-time record for swans nesting in the Sarkar system. Lloyd Roundtree, owner and pilot of Alaska Island Air in Petersburg, Alaska, said he has seen many swans on Sarkar Lake during the winter. If the Sarkar system is a nesting area for swans and a major wintering ground for large migratory waterfowl, the Sarkar system should be protected from the extensive habitat destruction resulting from logging activities or overdevelopment.

The main inlet, north shore is as extensive a stream as any seen in the entire Sarkar system and is a major spawning and rearing area. The main inlet is easy to walk once it becomes stream-like up about the 0.1 mile inlet slough. Fishing for cutthroat trout is good in inlets to Raven Lake and at the inlet of Long Lake.

There is real potential for a canoe watercourse in the Sarkar headwater lakes. The inlets and outlet coves all have narrow but navigable water. One could easily get a canoe into Long Lake. If a trail were constructed from the south end of Raven Lake and the north end of Finger Lake, a portage would be possible between these lakes.

DISCUSSION

Relationship of Limnological Characteristics to Fish Production

Lakes of the Sarkar system are quite shallow. Finger, Raven, and Tammy lakes have mean depths of 10.7, 7.1, and 10.0 m, respectively. Moss Lake is much shallower with a maximum depth of 4.5 m. About two-thirds of Moss Lake is covered by submergent or emergent vegetation. All lakes exhibit warm temperatures.

Water chemistry analysis shows that Moss Lake has a much higher productivity potential than the other lakes, as the alkalinity and conductivity are higher and pH is near neutral. Sarkar Lake has a shallow freshwater lens, but most of the lake is full-strength salt water. The bottom layer of Sarkar is anerobic.

A comparison of productivity by the morphoedaphic index shows Finger and Tammy lakes as the most productive studied in southeast Alaska to date.

Zooplankton samples collected from Finger, Raven, and Tammy lakes show an almost identical species composition. All three lakes contained populations of the Chaoborus sp. midge. These larvae and the larger copepods are normally selectively fed upon by rearing sockeye and coho salmon. The fact that this species of larvae was present throughout the summer indicates (1) a scarcity of rearing sockeye and coho salmon and/or (2) an abundance of these larvae due to the high productivity of the system.

No Chaoborus sp. or copepods were captured in Moss Lake although water chemistry analyses indicate this to be the most productive of the four freshwater lakes. This may be due to a dense population of rearing fish cropping off the larger zooplankton.

Calculations of the standing crop of net plankton indicate the Sarkar lakes to be quite productive when compared with others in southeast Alaska.

The Sarkar system contains coho, chum, pink, and sockeye salmon. Catches of sockeye and coho salmon in Sarkar Cove are summarized by Rich and Ball (1933) for the period 1897 to 1927. The high catch of sockeye salmon occurred in 1911 with a catch in excess of 69,000. The highest catch of

coho salmon was in 1904 at 17,000. No reliable estimates of escapement are available for recent years.

The waters of the Sarkar system appear well suited for cutthroat trout and coho salmon. Extensive inlet tributaries and rich plankton production in the lakes provide good rearing habitat.

Condition factor of resident cutthroat trout was 0.80 to 0.95. Fall immigrant sea-run cutthroat trout had a much higher condition factor of 1.25. Fish remains were the most abundant food items identified in cutthroat trout stomachs. Other organisms were eaten as availability allowed.

Recreational Analysis

The Sarkar system is unique in that it offers a different type of recreational opportunity not abundant in southeast Alaska. If developed properly, it could have an easily accessible area and a limited access area, both rich in mammalian and avian fauna. Both areas would afford the canoeist a fine opportunity for solitude and an opportunity to observe diverse riparian, aquatic, and terrestrial communities.

The more accessible area would be Sarkar Lake and its associated trail system. Sarkar Lake has an abundance and diversity of wildlife common only to a saltwater lagoon.

The restricted access area would be the upper lakes canoe area comprised of Tammy, Finger, and Long lakes. This would be accessible as a fly-in area or by portage from the head of Sarkar Lake.

Fisheries resources of the Sarkar system are diverse with coho, sockeye, pink, and chum salmon, steelhead and cutthroat trout, Dolly Varden, cottids, stickleback, and several saltwater species. Resident cutthroat trout are present in all lakes, so the serious angler could always eat trout.

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